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Forthcoming Events.

OCTOBER 18.

Institute of British Foundrymen (London Branch):—Ordinary meeting in London. "Foundry Research," Paper by J. G. Pearce.

OCTOBER 21.

Institute of Marine Engineers:—Ordinary meeting in London. "Present Tendencies in Steam Generation," Paper by Sir Jas. Kemnal.

Sheffield Metallurgical Association:—Ordinary meeting at Sheffield. "Notes on Hot Rolling," Paper by G. M. Brown, M.A., B.Sc.

OCTOBER 23.

Sheffield Metallurgical Association:—Ordinary meeting at Sheffield. "Body in Steel," Paper by J. Kent-Smith, O.B.E.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

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The American Foundrymen's Association Conference.

The Annual Conference of the American Foundrymen's Association, which opened last Monday at Milwaukee, is to have a number of papers presented to them which are of very direct interest to our readers. It is obvious, even from a perusal of their titles, that the majority of problems connected with foundry work are everywhere of the same type, and their solution will probably be through international co-operation. The reason for this is because they are attacked from different angles, and the use of different raw materials; therefore, when similar conclusions are arrived at both in America and Europe, they can be regarded as being correct in the light of modern knowledge and conditions. This is why the most enlightened foundrymen throughout the world attach so much importance to the annual interchange of technical papers between the technical foundry organisations in France, Britain, Belgium and America. It is a little disconcerting to note that there is no paper from Belgium being presented to the A.F.A. Conference. To be platitudinous, it is easier not to organise for the exchange of a paper than to go to a small amount of trouble to secure a suitable lecturer. The paper from the British Association this year is one on Bell-founding, by Messrs. Wesley Lambert and George Hall, and is typical of the work done by the Association on whose behalf it is given, as it describes the glamour of the ancient craft, its modern practical aspects and some of the underlying metallurgical principles. Dr. Guillet presented the French Exchange Paper, which deals with Alpax.

Apparently, American foundry thought, like British, is being devoted to the ascertaining of whether certain types of pig-iron possess inherently good properties. According to one author they certainly do, which persists even after twice remelting. Another phase is the ascertaining of knowledge as to what happens to steel scrap charged into the cupola. The practical object sought is to provide information so that the foundryman can specify the most suitable size of scrap with the assurance he is using the most economical. The American Society for Testing Materials Standard Test bar for cast iron has been subjected to tests. This work, of course, is of international importance, as it will help in the final decision as to the most suitable test piece to employ for international business.

The question of moulding sands is always rightly regarded as of paramount interest in American foundry circles, and a national (or should it be continental) committee is constantly studying the matter and reporting. "Broadening the Field for Steel Castings" is the title of one paper presented. If such a paper was given to a British technical organisation, it would probably receive the title "The Influence of Special Elements on Iron-Carbon Alloys in the As-Cast Condition."

This is an excellent example of the close touch which the American research worker maintains with industry, a condition which does not obtain so generally as industry could wish in this country.

No less than 58 papers and reports were submitted during the Conference. This is roughly half the annual output of the British Association, but the latter does the major portion of its work, whilst the former, at the moment, has no branches. This matter is, however, under discussion.

XUM

A System of Foundry Organisation and Cost Recording.

By M. Nicholls.

The owner of a foundry was recently asked if he could undertake the production of certain castings. He had never handled anything of the kind before, but so sure was he that his foundry could do what was required that he not only assented, but forthwith gave a price, which was so low that it aroused suspicions in the mind of the prospective buyer. A trial order was, however, given, but at the end of two weeks the enterprising foundry owner was forced to confess that he would have to increase his price 100 per cent. in order to produce what was required. At the end of a further two weeks he asked the buyer to cancel the order, as it was impossible for him to produce satisfactory castings *at any price*.

Another foundry owner was asked if he could produce the castings, and he "thought he could." He was shown a similar casting produced in another foundry, and was asked if his product would be equal in finish to the one exhibited, but "he had his doubts about it." He was not anxious to make the attempt, and quoted a price that effectively precluded him from having the opportunity.

Each of these men was at the head of an industrial undertaking, and neither was cognisant with what his foundry could do. The fact was that in each instance there was no effective works organisation, and as a consequence it was impossible for anyone to determine the effective capacity of the foundry. It may be urged that the subject of the second illustration was quite justified in refusing to commit himself, but the fact that he wanted work, yet was averse to extending himself in order to get it, stamped him as being lacking in enterprise, and lacking also in real knowledge, for the casting in question was being produced in a foundry certainly no bigger, and apparently no better equipped, than his own.

It was the writer's privilege to visit these foundries, and he came to the conclusion that if they had been efficiently organised, output would have been increased, and of a much wider range. The office accommodation was meagre in the extreme; the "booking" was done by a foreman, and although in each instance time recorders were installed, these did not appear to be utilised for the purposes of costing. As a matter of fact, there was no costing system at all (or at best only a very elementary one), no system of progressing the work, and no record of patterns.

Happily, however, all foundries are not similarly conducted, and the writer had the privilege of visiting another foundry where the organisation, though not elaborate, was nevertheless sufficient for the need. It is proposed, therefore, to give some details of this organisation in the hope that they will interest those foundrymen who are anxious to improve matters so far as their own foundries are concerned.

In the first place, it was recognised that it was impossible to quote intelligently for orders unless there were means of knowing what similar (or somewhat similar) castings had cost to produce. It is, of course, apparent that the general founder is constantly being asked to quote for castings to designs he has not hitherto handled, but, even so, the data he has at his disposal by way of costing records is of value, for it furnishes the basis upon which a quotation can be made. The costing record was perhaps rather crude, but it sufficed, the essentials being (*a*) actual cost of material plus a percentage for receiving, storing and melting, which gave the cost of the metal; (*b*) actual cost of the operations (core-making, moulding, inspection and fettling), plus a percentage for handling (including casting), supervision and administration, which gave the cost of production; (*c*) a percentage added to the cost of production for on costs to cover factory rent, rates, etc., lighting and power, plant upkeep, workmen's insurance, compensation and welfare, which gave the total cost of manufacture. A form used for costing purposes (labour) is illustrated by Fig. 1.

The foundry boasted a progress department which, as a matter of fact, constituted the whole of the office organisation except estimates and sales, and the actual payment of wages. This department handled time-keeping, ordered material, issued all job orders, followed up the work in progress, and ultimately posted the costs against the specific job. Immediately an order was received particulars were entered upon a card, similar to Fig. 2, which was filed in alphabetical order under the customer's name. This record was kept up to date by entries relating to the progress made, so that at any time it was possible to know the true state of affairs in connection with any specific order. These entries were made from particulars furnished by the section foreman upon charts about to be described, and were checked weekly with the workmen's job orders, which were received in the office prior to being passed for payment.

The chart illustrated by Fig. 3 was made out daily in the progress office, and posted in the foundry. On one side it gave particulars of the cores to be completed during the day and on the other side what moulding was to be completed. The respective foremen were expected to enter the number made during the day in the appropriate column, whilst the inspector was responsible for entering the number passed. The chart with these particulars had to be returned to the office before 9 o'clock on the following morning, and from this entries were made upon the customer's order card (Fig. 1). A new chart was then made out, the first entries (in red) denoting uncompleted work in connection with the preceding chart. This chart enabled the foremen to concentrate upon the most urgent work, and ensured the claims of each order receiving proper attention.

The inspector's daily report on all castings passed to store appeared upon a sheet similar to Fig. 4, and the fettler's daily return is illustrated by Fig. 5. The inspector's report covered all castings submitted to him, and included those which were consigned to the rumbler without receiving individual attention at the hands of the fettler. On the other hand, the fettler's return also included castings which were obviously scrap, and were not, therefore, submitted to the inspector; also castings which, after fettling, had to undergo a sandblasting or a pickling process; these ultimately appearing upon the inspector's report at the completion of this process.

For the use of the pattern-maker the chart illustrated by Fig. 6 was exhibited, this giving particulars of all new patterns and of repairs to existing patterns. The top portion of the chart was devoted to wood patterns and the lower portion to metal patterns.

The organisation thus described was effectively exploited, and was valuable, both from a production and a costing standpoint. It is, of course, evident that costing records are valueless unless they are reliable, and it is only by controlling production at every stage that accuracy is assured. The charts in the first instance gave the sequence in which the work was to be handled; in other words, it was the instruction, and then it was the foreman's duty to show that the instruction had been carried out. Assuming that he could handle more in any one day than the instruction covered, the matter was remedied after a visit to the office, which would result in further orders being added to the chart.

By means of a comparatively small outlay (for only two clerks and a junior were employed in the progress office), the capabilities of the foundry were well known to the proprietor, who was thus enabled to avoid pitfalls when quoting for further work, and also to become enterprising in the true sense of the word, seeing that he knew in what direction to move.

WORKS COST RECORD

Job No.		CORES					MOULDS					FETTLING					INSPECTION					COST SUMMARY			
																						Labour cost.	On costs	Metal cost	Total cost
	Time																								
	Rate																								
	Time																								
	Rate																								
	Time																								
	Rate																								
	Time																								
	Rate																								
	Time																								
	Rate																								

FIG. 1.

CUSTOMER'S ORDER RECORD

*Customer*_____ *Works Order*_____ *Delivery*_____

Pattern No.	Qty.	W.O. Recd.	Pattern recd.	Pattern Examd.	Operations & rates listed	Cores completed		Moulds completed		Castings passed inspection		Castings despatched	
						Date	Cost	Date	Cost	Date	Qty.	Date	Qty.

FIG. 2.

TO-DAY

*Date*_____

CORES

Job No.	Pattern No.	Qty.	Particulars	Qty. made	Qty. passed

TO-DAY

*Date*_____

MOULDS

Job. No.	Pattern No.	Qty.	Particulars	Qty. made	Qty. passed

Enter in Red all uncompleted Orders on Previous Day's List.
RETURN TO OFFICE BEFORE 9 A.M. TO-MORROW.

FIG. 3.

INSPECTOR'S DAILY REPORT

*Date*_____

Job No.	Patterns passed	Quantity passed	Quantity rejected	Remarks

FIG. 4.

FETTLERS DAILY RETURN

*Date*_____

Job No.	Pattern No.	Qty. completed	Qty. passed	Qty. rejected	Remarks

FIG. 5.

PATTERN MAKING AND REPAIR

Date	Job No.	Pattern No.	Name	To be completed by	Drawing Recd.	Pattern in hand	Pattern completed	Passed inspection	Painted	Sent to Store

METAL PATTERNS

Date	Job No.	Pattern No.	Name	No. of patterns reqd.	To be completed by	Master pattern checked	Casting in hand	Castings made	Castings machined	Passed inspection	Checked in Pattern Shop.	Sent to Store

FIG. 6.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Irish Foundry Conditions.

To the Editor of The Foundry Trade Journal.

Sir,—In your leading article commenting on my letter dealing with "Foundry Conditions in the Irish Free State," published in your issue of October 9, you state that I infer "that the reports issued by the National Physical Laboratory and the British Cast Iron Research Association are of a highbrow character, incomprehensible to the average foundryman." No such suggestion was meant, but rather that isolated reports do not, and cannot, take the place of live local interest and routine scientific control.

Moreover, a certain amount of knowledge is requisite before the desire to take part in the activities of such institutions can exist. You state that no iron founder in the Irish Free State takes part in these activities, and I simply reply that a certain amount of local work of a "missionary" nature is necessary before it is likely that the iron founders in this country will co-operate in a manner useful either to the societies or to themselves.

Specific examples may make the reason clear:—

(1) A Dublin ironfounder was engaged on the production of thin hollowware castings, and got into dire trouble, his castings being hard. He stated that the pig was supplied as No. 1 hematite, but the fracture was quite close-grained. I sampled and had an analysis done. The consignment varied somewhat, with silicon running between 2 to 2.5 per cent. with 0.8 per cent. manganese; otherwise the iron was a low-phosphorus hematite pig.

The reason for his trouble was obvious, and would have been obviated if it had been customary to analyse the materials used.

(2) Another foundry advertised "Semi-Steel" as one of their specialities. I asked to see tests, and was shown the one and only transverse and the one and only tensile. I could not get any information as to test-piece size, and, moreover, it transpired that they had not had the metal analysed, as the local college could not undertake the work, and the British Cast Iron Research Association, who had apparently been consulted, wanted £2 2s. for a straight cast-iron analysis.

I asked "But what will it cost you if you buy a fresh lot of pig-iron, are let down, and find that your next cast is of an entirely different composition and your castings scrap?"

These two cases are by no means exceptions; they are, in fact, types!

Reference is made in the leading article to the "Special Library," and it is stated that even quite a small foundry can send a sketch showing a defect, and receive advice as to the best method of remedying it. Naturally this is a benefit to the founder, but it is a matter of most common experience that if the Institution offering such advice is distant, there is a tendency to consult it, after the defect has arisen, instead of appealing to it in time to prevent the trouble arising.

I do not wish to belittle the merits of existing British efforts. There has been a great advance, particularly in recent years, but I must point out that the Institutions referred to in your article have for some reason failed to attract the Irish founder, and I offer the suggestion that it is only by encouraging local effort in Ireland that international institutions can be made attractive.

I must confess that I myself feel up against something very like a stone wall, but shall persist in recommending local effort, scientific propaganda, etc., on the spot, and the creation by the Irish Government of an institution capable of serving as an information bureau, and doing routine analysis at a nominal charge.

The idea is no new thing. It has been done at the National Seed Testing Station, and farmers have learned its value. It is being done by the Irish Agricultural Organisation Society, who run a laboratory for testing the purity of milk, and its suitability for butter- and cheese-making, and gives advice to creameries on technical points.

These local efforts have been successful. The institutions are in daily touch with the trades they are created to help. Why not extend the system to the very lame foundry trade? It needs help! I repeat that research institutions are excellent and necessary, but while acknowledging this, I state again that what is most needful in Irish foundries is local and at the moment rather commonplace missionary effort.

It serves the trade but poorly to draw a red herring across the trail of a man who is doing his utmost, under very great difficulties, to get attention paid to absolute rock-bottom fundamentals.—Yours, etc.,

H. Gratten.

45, Synge Street, Dublin.
October 11, 1924.

Barrhead Foundry Fire.

A destructive fire broke out early on Saturday morning last in the Grahamstone Foundry, Barrhead, Renfrewshire, belonging to John Cochrane (Barrhead), Limited.

The fire was first discovered in a small pattern store. In a few minutes the flames spread to an oil store, and from there to the general store, fitting shop, and offices. There was a strong wind blowing, and this carried the flames to two buildings adjoining the main workshop. One was only a wooden shed, but the other was a brick building used for storing patterns. The Glasgow and Paisley firemen endeavoured to save the latter building, but the strength of the wind and the fierceness with which the fire was burning in the main building made their efforts of no avail. Within twenty minutes the roof had collapsed, and the whole building was a mass of flames. The moulding shop, however, was saved.

Over two-thirds of the foundry was destroyed, the walls collapsing in parts. There were no workmen on the premises at the time. For some months the foundry has not been fully employed, but about 60 men will be thrown idle. The damage is exceedingly heavy.

French Foundrymen's Association.

The annual Convention of the Association Technique de Fonderie will be held at Paris in the Grand Hall of the Conservatoire des Arts et Metiers, 292, rue Saint Martin, on November 21, 22 and 23. Amongst the subjects to be dealt with are:—Pattern standardisation; standardisation of costing methods; uses of special pig-irons; scientific and experimental study of pig-irons, and foundry defects.

There will be a banquet on the last day (Sunday) of the Conference. On behalf of the Institute of British Foundrymen, Professor A. Campion is giving a Paper on "Some Factors which Influence the Strength of Cast Iron." Another Paper is being read on "Special Pig-Irons" by Mr. H. Shillitoe, managing director of British and Continental Traders, Limited, and a member of the Council of the London Branch of the Institute of British Foundrymen.

The French Association hope that there will be a strong delegation from the British foundry industry.

Thomas E. Gray & Company, Limited, of 119, High Holborn, London, W.C.2, have discovered a further seam of their well-known Silacene refractory, and state that they have now a proved reserve of over 10,000,000 tons.

Chinese Moulders in Hongkong. — Chinese moulders and casters employed at docks and other engineering establishments in Hongkong recently petitioned their employers for a 60 per cent. increase in wages. About 1,000 workers were represented by the petition, which says wages received by mechanics in Hongkong are lower than in other cities of the Far East. The average skilled worker in moulding and casting shops earns about 2s. 6d. a day in Hongkong.

Notes on Pearlitic Cast Iron.*

By J. E. Hurst.

The term pearlitic cast iron applied to what is presumably a new type of cast iron was brought to the notice of the foundrymen in this country within the last year or so by the translation of an article by Professor Bauer describing the work of Diefenthaler at the Lanz Foundry, Germany. This article appeared in The Foundry Trade Journal, June 7, 1923.

In a further letter to The Foundry Trade Journal,[1] Professor Bauer gives a more concise definition of pearlitic cast iron. He considers pearlitic cast iron to be the product of a certain special and novel process for the production of cast-iron castings, and he defines it as follows:—

"By the 'pearlitic casting process' it is possible to produce a grey iron on solidification from a pig-iron low in carbon, phosphorus and silicon, which under ordinary circumstances would solidify white, and that at the same time, due to the low total carbon content, a microstructure is produced which consists of a pearlitic matrix with enclosures of free graphite."

This definiton is more or less confirmed[2] by the remarks of H. T. Meyer, one of the departmental heads of the Lanz Foundry, who states that the iron "when cast normally" should show "a white fracture when cold." This state of affairs is presumably brought about by the use of irons with low silicon content; but in addition it is evident from a further article[3] that a low content of both carbon, manganese, and phosphorus is also desirable. For some reason or other various writers have laid considerable stress on the fact that it is immaterial whether the irons have a high sulphur content or not.

The information available on the method in which castings are produced to comply with the requirements of the foregoing definition of pearlitic cast iron is outlined in the British Patent Specification of Diefenthaler. This is to be found in abstract in The Foundry Trade Journal,[4] and states "that the invention can be carried into effect satisfactorily by bringing the mould preliminarily to a definite temperature. It has been found, for example, in the case of an iron of the following composition:—Tot. C. 3.00, Gr. 2.15, C.C. 0.85, Si. 1.00, Mn. 0.70; S. 0.10, P. 0.40, and Fe. 94.80 per cent., that the mould should be reheated to a temperature according to the thickness of the section of the casting as follows:

"Thickness of section, about 10 mm. to about 200 deg. C.; thickness of section, about 20 mm. to about 150 deg. C.; thickness of section, about 30 mm. to about 100 deg. C.

"If the composition is different; for example, if it is of the following composition:—Tot. C. 2.80, Gr. 1.95, C.C. 0.85, and Si. 0.80 per cent., the preliminary temperature of the mould should be selected about 40 to 50 deg. C. higher, that is to say:—

"Thickness of section, about 10 mm. to about 240 deg. C.; thickness of section, about 20 mm. to about 195 deg. C.; thickness of section, about 30 mm. to about 145 deg. C.

"It may be seen from these examples that it is a comparatively simple matter to prepare scales or curves for a particular composition from which without further trouble the necessary temperature of the mould can be read for a particular thickness of material."

Alternative methods of carrying out the process to produce the Lamellar pearlitic structure consist of:—(1) Heating the mould by inserting the mould after casting in a heated chamber; (2) heating the metal to a higher initial temperature.

This is broadly all the information available on pearlitic cast iron and the process whereby it is produced, and the whole of this may be conveniently summarised again in the following words:

Pearlitic cast iron is a cast iron having essentially a low silicon and low total carbon content. This cast iron, when cast normally, would have a white fracture, but when cast in warm moulds or cooled slowly in the mould under special conditions has a structure consisting solely of pearlite and graphite. The composition and rate of cooling are varied to comply with these conditions for any particular thickness.

In endeavouring to consider pearlitic cast iron privately, let alone discuss it in a Paper of this nature with a view to forming some opinion as to the nature and value of this material, there is at once evident a serious difficulty of the lack of essential information.

The first question arising is, what is the difference between pearlitic cast iron and ordinary castings containing an all pearlite-graphite structure of which many hundreds of tons of castings must have been made in the ordinary course of foundry practice daily? This question is at once answered by the definition, and it is important to be clear on this point. By the definition it is stated that pearlitic cast iron is essentially of such a composition that for any given thickness of section when cast under the ordinary rules of sand casting the finished casting would have a hard, white fracture. This fact at once differentiates between an ordinary cast iron of a pearlite-graphite structure and the product now known as pearlitic cast iron. There has evidently been some confusion on this point, and the Editor of The Foundry Trade Journal has suggested the special term of Lanz pearlitic cast iron to be used to cover the product of the Diefenthaler patent. This modification in the title is, apart from anything else, an act of courtesy justifiable under these circumstances. The very scanty information available on the Lanz pearlitic cast iron has already been mentioned as a difficulty in profitably discussing this subject. The writer proposes to discuss such information as he has been able to obtain both as regards the production and properties of this material, and to discuss generally some of the principles which might be considered to underlie the idea of pearlitic cast iron.

Before doing this, the writer feels it to be his duty to call attention to the considerable amount of looseness met with in the technical writings concerning this material. For example, it appears redundant to specify a content of combined carbon in the description of a cast iron in the text of a patent which is concerned with ensuring that cast iron shall have an all pearlite-graphite structure. Such statements as the production of a casting "according to the rules of the iron-carbon crystallisation doctrine, and conducting its cooling in such a way . . . etc.," are extremely loose and without meaning. Such looseness of expression is apt to give the impression of quackery and certainly tends to lower the subject in the estimation of the thinking foundrymen.

Properties of Pearlitic Cast Iron.

The properties claimed for pearlitic cast iron produced according to the Lanz process are summarised as follows:—(1) High tensile, transverse strength and toughness; (2) high resistance to impact stresses; (3) moderate hardness when properly treated; (4) only a slight tendency to the formation of pipe; (5) great resistance to sliding friction (abrasion); (6) fine dense structure, the structure being unaffected by temperature changes, and (7) a certain amount of ductility, viz.: (0.8 per cent. elongation) is claimed, and in several places it is mentioned that pearlitic cast iron is replacing malleable castings for many parts.

The first six of the above items are abstracted from Professor Bauer's Paper already referred to, whilst the last item will be found mentioned on several occasions in the various articles relative to pearlitic cast iron which have appeared in The Foundry Trade Journal.

Professor Bauer gives a series of test figures obtained on Lanz pearlitic cast iron. The tensile strength and hardness determination converted into English units are given below:—

Tensile Strength.—"A." 22.23 tons per sq. inch. "B." 24.1 tons per sq. inch.

Hardness (Brinell).—"A." 152. "B." 155.

* Paper read before the London Branch of the Institute of British Foundrymen, Mr. V. C. Faulkner presiding.

[1] F. T. J., December 13, 1923.
[2] F. T. J., August 14, 1924.
[3] F. T. J., August 30, 1923.
[4] F. T. J., August 30, 1923, page 186.

These determinations were obtained on test bars turned from dry sand castings approximately 1¼ in. and 1⅝ in. dia. respectively by 29½ in. long. The composition of the pearlitic cast iron was as follows:—Tot.C. 3.25, Gr. 2.41, C.C. 0.85, Si 1.11, Mn 0.79, S 0.154, and P 0.40 per cent.

These test figures are undoubtedly remarkable, and whilst equally as high strength figures have been often obtained, there is as yet no definite method to be followed which will ensure regularly obtaining such values from test bars of such dimensions. A further striking fact is, that these high tensile strength values are accompanied by a comparatively low Brinell hardness figure.

The highest recorded authoritative value for the tensile strength of cast iron of which the author is aware is that of the synthetically produced cast iron described by Keller.* This cast iron is recorded as having a tensile strength of 50 Kg. per sq/mm. or 31.7 tons per sq. in. Unfortunately, the complete composition of this is not available, but another recorded case is added in Table I. This is a sample of Swedish pig-iron recorded by Dr. Swinden in 1909.

TABLE I.—*Compositions of High Tensile Strengths Cast-Iron.*

Tensile strength	"A" 19.2 Tons per sq. in.	"B" 31.7 Tons.	"C" 24 Tons.
Tot. C. ..	2.60	2.90	3.25
Gr.	2.40	—	2.41
C.C.	0.20	—	0.85
Si.	2.80	1.75	1.11
Mn.	0.60	0.50	0.79
S.	0.15	traces.	0.154
P.	0.50	0.50	0.40

"A"—Swinden, 1909. "B"—Keller, 1919.
"C"—Pearlitic Cast Iron.

The comparative figures given in Table I serve to show the remarkable feature of the high tensile strength of pearlitic cast iron. Contrary to what we should have expected we find that the total carbon contents are quite normal, and in this respect the pearlitic sample differs from the other samples recorded.

In spite of the high tensile strength of the pearlitic sample there are one or two disappointing features in connection with this and also Professor Bauer's comparison of test results. Firstly, it has been shown that the composition of the pearlitic sample is not strictly in accordance with either the Patent Specification or the opinions of the authorities who have written on this subject. The total carbon figure is higher than would have been expected in view of the emphatic declaration on this point above. The same remarks apply to the silicon content, and it is certain that a cast iron of this composition cast into dry sand moulds, into test bars 1¼ in. dia., would not of necessity have had a white fracture. These considerations at once upset our ideas of pearlitic iron gained from the definition which has been made so emphatically by the authorities on this subject.

Professor Bauer's results would have been of much more value and would have given more striking evidence of the value of the pearlitic process if he had published a comparison of the test results on the pearlitic iron cast according to the method of the pearlitic process and the same iron cast in the ordinary way.

Further, these results would have been of far more value than the comparison he gives with other cast irons, the composition of which have nothing in common with the pearlitic sample, nor can they pretend to be typical examples of the best practice in this class of work they are supposed to represent.

* J. I. S. I., No. 2, 1919.

In connection with this, the writer turned up the analyses of two different makes of gas-engine cylinder liners. These analyses were made about the end of 1915 from three liners which came under the writer's notice as having given extraordinary satisfaction in life and service in the engine. Samples Nos. 1 and 3 are by the same maker, and sample No. 2 by a different maker. No. 4 is the composition of Bauer's sample of pearlitic cast iron.

The combined carbon contents of No. 1 and No. 2 are not so high as recommended for pearlitic cast iron. Sample No. 3 more closely approaches the composition of Professor Bauer's sample No. 4, and only differs seriously in the sulphur, manganese, and phosphorus contents. Neither the tensile strength or hardness value coincide with those of Professor Bauer's pearlitic cast iron. It is important to bear this difference in mind, and it is proposed to discuss this more fully later. Incidentally, these samples, which were taken from cylinder liners in no case more than 1-in. thick, serve to confirm the fact that such low silicon irons cast in the ordinary way need not necessarily be white irons.

Professor Bauer gives a complete list of the physical properties, including transverse and impact tests, all of which are in keeping with the high tensile strength value recorded above.

The resistance to wear of pearlitic cast iron is claimed to be one of the outstanding properties. In this connection it must always be borne in mind that wear is a relative property, and must strictly be considered in conjunction with the conditions under which the wearing part is operating and with the wearing body itself. Many curious cases of resistance to wear can be quoted in irons which have anything but a pearlitic matrix. In spite of these, however, it is, generally speaking, well known that an all-pearlitic structure is advisable for the best general resistance to wear.

Ductility.

It has already been mentioned that it is claimed to be possible to substitute pearlitic cast iron for malleable castings. This claim must be considered very carefully, and unless this is done it is liable to be a gross misstatement. The high tensile strength results alone would not justify this material replacing malleable castings, and even 0.8 per cent. elongation is hardly sufficient to allow of the claim that pearlitic cast iron is an efficient substitute for malleable castings. It is not certain how the 0.8 per cent. elongation was measured, nor is there available the composition of the sample on which this result was obtained. It is a higher value than generally met with in cast iron, which may be taken as showing an elongation of 0.0131 to 0.0215 in. on 8 in., or 0.163 per cent. and 0.27 per cent. respectively. These values are given by Dr. Unwin.

TABLE II.

No.	Tot. C.	C.C.	Gr.	Si.	Mn.	S.	P.	Tensile. Tons.	Brinell.
1. Mouth End	3.25	0.59	2.66	1.16	0.80	0.072	1.00	17.9	228
Exp.: End	3.38	0.64	2.74	1.23	0.89	0.071	0.93	—	207
2. Mouth End	3.39	0.71	2.68	0.96	1.04	0.080	0.93	18.1	228
Exp.: End	3.32	0.68	2.64	0.93	0.95	0.073	1.18	—	228
3. Mouth End	3.33	0.87	2.46	0.98	1.10	0.09	0.89	18.25	228
Exp.: End	3.34	0.90	2.44	0.98	1.13	0.08	0.81	—	228
4. ——	3.25	0.85	2.41	1.11	0.79	0.154	0.40	24	155

Chemical Composition.

Two features in the chemical composition of pearlitic cast iron are repeatedly stressed in the writings on this subject. These features are the necessity for a low total carbon and low silicon content. In an article* translated from "Die Gieserei" it is stated that the total carbon content "must definitely be between 3.0 and 3.1 per cent., and the silicon and manganese contents are specified as being in the region of 1.5 per cent. and between 0.7 per cent. and 0.8 per cent. respectively. It is important to note the emphatic way in which the total carbon content is specified.

Further examples quoted in an article previously referred to give total carbon contents of

* F. T. J., August 2, 1924, page 96.

3.00 and 2.8 per cent. respectively, and the condition of low total carbon and silicon contents are again pointed out. These latter are low values from regular cupola melting practice, and in this connection the author has been verbally informed that the inventors consider the use of open-hearth furnace melting as desirable, in fact, almost a necessity.

The manganese content is specified in the former case, but from the articles which have been available to the author, he is not sure that

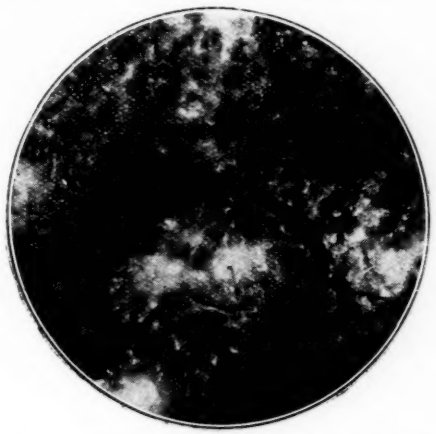

Fig. 1.—Cast Iron Heat-treated, showing Plates of Primary Graphite and Nodules of Secondary Graphite. Magnification 100 dias. Etched HNO_3.

sufficient importance has been attached to either this constituent or the phosphorus constituent. Any attempt to secure a constant pearlitic structure amounts to the same thing as attempting to obtain a constant combined carbon. If all other things are equal, any variation of the manganese and phosphorus contents will have an effect on the amount of combined carbon, and consequently the amount of the pearlitic constituent present in the final iron. An increase in both these constituents, other things being equal, tends to lower the amount of combined carbon present. The necessity for specifying the limits of these constituents is at once apparent.

It is also stated, as an advantage of the pearlitic process, that a higher sulphur content can be used without detriment. This is probably quite true, but again it is obviously important that some limits should be specified for particular conditions, otherwise it appears impossible to guarantee the production of a correct all-pearlitic structure.

When these instructions are taken into consideration along with Professor Bauer's experiments on the strength properties, in which test bars were cast of 1⅜-in. dia., it is somewhat disappointing to find that they hardly appear to comply with the conditions stated in our definition. Our definition appears to be correct, as it is taken direct from Professor Bauer's writings, yet the compositions above specified and actually used by Bauer would certainly be grey when cast in the ordinary manner in test bars 1⅜-in. dia. Cast in a thinner section, say about ¼ in., in a monobloc motor-cylinder casting, it is probable that this composition would have a white fracture, which leads us to one of the serious omissions in the information available of the Diefenthaler process—that is, that the limits of chemical composition have not been specified for the different sections of castings.

To illustrate this point, if one imagines an exceptionally thick casting, say a roll casting, of some 6 in. thick. If this were cast in the composition mentioned in the Diefenthaler patent, it would follow, if the extrapolation of the temperature thickness of section data in a linear manner is legitimate, that this should be cast in a mould of a temperature somewhat below zero. This is obviously not intended, and the correct procedure would be to adopt new limits of composition for the thicker sections of castings.

Sufficient has been said to illustrate how seriously the lack of essential information and the difficulty of correlating what published data is available, affects us in forming a definite opinion on the nature and advantages of the alleged pearlitic casting process. Before discussing certain general aspects arising out of this discussion, it is of advantage briefly to summarise the position we have arrived at. *Firstly*, the definition of pearlitic cast iron, the product of the pearlitic cast-iron process as designed by Diefenthaler, is perfectly clear, but the examples quoted do not appear to comply strictly with the terms of this definition, or with perfectly clear and ostensibly authoritative instructions given by certain writers on the subject. *Secondly*, it is to be regretted that the perfectly clear and obvious method of demonstrating the advantage of the pearlitic casting process, by comparing the physical test results on the same cast iron before and after the pearlitic casting process has not been adopted, at least in any published writings which have been available to the author.

There are, however, quite a number of points arising out of this discussion which are worthy of consideration, and the writer has selected what appear to him to be the most important to be dealt with here.

The first point which is of immediate importance to foundrymen in general is the fact that the pearlitic cast-iron sample of Professor Bauer's is a high tensile strength iron, and if regularity can be ensured in the production of such high tensile strengths in cast iron by this process, then this process is worthy of very serious attention. A most important additional point is that this high tensile strength is secured with a comparatively low Brinell hardness. Cast iron is very commonly produced to-day by ordinary foundry methods of cupola melting and sand casting, having a tensile strength in the neighbourhood of 20 tons per sq. in. It cannot be said yet, however, that regularity of such results can be guaranteed, in confirmation of which it might be said that no foundryman would agree to a specification embodying a tensile strength of 20 tons per sq. in., particularly when determined on a sand-cast bar of 1⅜-in. dia. Such results when they are obtained are the direct result of careful attention to a number of details so far as they are known to influence the tensile strength result. For example, foundrymen generally commence to lower the silicon, total carbon, and phosphorus contents either individually or as a whole. Special care is taken with the casting temperature within the limits of cupola melting practice, and it

Fig. 2.—Cast Iron Heat-treated, showing Secondary Graphite Formation. Magnification 500 dias. Etched HNO_3.

should be mentioned that a considerable amount of information is available on the influence of casting temperature both within and outside the range of cupola melting practice. These are now fairly well-known general methods of attacking the problem of producing high-strength cast irons, and as far as is clear to us, the pearlitic casting process uses these general methods, in addition to making an attempt to control the rate of cooling. Whilst, broadly speaking, foundry metallurgists are well aware of the influence of

rate of cooling on the constitution of cast iron, none of us have been aware of the fact that the rate of cooling could be modified in the manner proposed in the pearlitic cast-iron process, and for such a modification to be accompanied by such gratifying results.

The inference which should be carefully guarded against is that the superior properties are entirely due to the pearlitic structure and is open to quite a number of objections. In the first place, the writer has quoted a single case already in Table I of an iron having a pearlitic structure giving lower results than the authentic pearlitic cast iron. Other similar cases can be readily quoted, and, conversely, cast irons having quite a large quantity of free ferrite or excess cementite, giving equally as high results as pearlitic cast iron, can be readily quoted, but we may conclude at once that the pearlitic structure is not solely responsible for the high strength figures. The analogy drawn between the strength of cast iron and steel of increasing pearlite content is not legitimate, as the overwhelming influence of free graphite in the mechanical properties of cast iron is well known. The size, quantity, and distribution of the graphite, and, what is not necessarily the same thing, the grain size, are the important features in determining the mechanical strength of any given cast iron, and the writer believes that were the subject of pearlitic cast iron possible of rigid investigation, it would be shown that these were still the controlling factors.

It must not be lost sight of in this connection that, if the definition of pearlitic cast iron is correct, the least thing the inventors of the pearlitic process can do is to obtain a pearlitic structure as being the only structure which could be reasonably machined.

The definition of pearlitic cast iron is particularly intriguing to certain sections of the iron-founding industry. One of these—the motor-car cylinder founder—will surely be interested in the possibility of reducing his silicon content to such a low figure, and still obtain a machinable casting without any apparent increase in his casting difficulties. At the other end of the scale the roll founder and heavy casting manufacturer will be delighted at the possibility of ensuring at least a uniform pearlitic structure throughout the whole cross section of the very heavy castings with which he is called upon to deal.

In the former case at least two other properties in addition to machinability, high tensile strength and good casting qualities are desired. These are

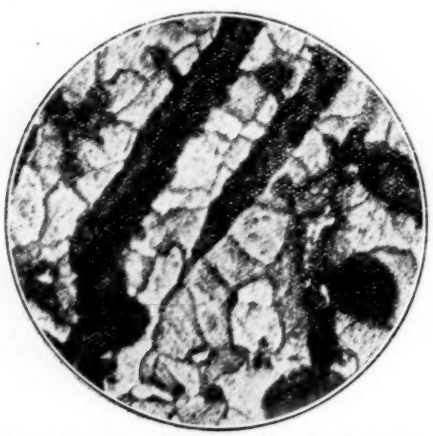

Fig. 3.—Head from Large Column Castings. Magnification 84 dias., showing Large Graphite and Crystal Boundaries. Etched HNO_3.

resistance to wear and resistance to distortion under heat influences.

The writer has already indicated the difficulty of discussing the question of resistance to wear. This difficulty is that it cannot be discussed with reference to one component only of the wearing conditions. The writer's present opinion on this subject is that, generally speaking, in engine cylinder practice where cast iron is working in contact with cast iron, the best practice, at least so far as sand castings is concerned, is to use cast iron free from free ferrite and having the smallest grain size. That is to say that an all pearlitic matrix (apart from the phosphide and sulphide constituents) is the best practice.

Further, it is the writer's experience with many cylinder problems of recent years that the lower the silicon content apart from any consideration of the combined carbon or pearlite content, the better the resistance to wear under almost all conditions appertaining in engine cylinder work, internal-combustion engine or otherwise. From these points of view the pearlitic cast iron structure and

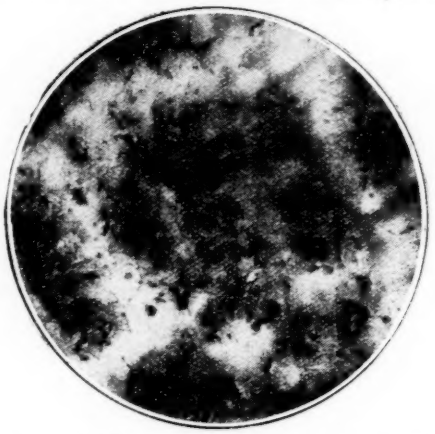

Fig. 4.—Low Phosphorus Cast Iron. Etched Stead's Reagent, showing Network Formation of "the Cast to Solidify" Portions of the Cast Iron.

the underlying features of the Lanz pearlitic cast iron as defined, in the author's opinion, fully justify their claims regarding resistance to wear. Although the writer is not yet in a position to express a really authoritative opinion, it should be pointed out that the low silicon and all pearlitic structure accompanied by the low Brinell hardness, are a set of conditions that might be expected to give better results than the same conditions only with a high Brinell hardness.

The distortion of cast iron under heat influences in the engine cylinder is another complex phenomenon, and the writer has already shown that this is in part due to the gradual decomposition of the pearlite constituent yielding free graphite even at the comparatively low temperatures prevailing in engine cylinders.* It was shown here, and has since been confirmed by other investigators (Donaldson) that the lower the silicon content the greater the resistance of the pearlite constituent to decomposition under these circumstances. It is the writer's opinion that a low silicon and all-pearlitic structure such as accompanies pearlitic cast iron are desirable conditions to obtain the best resistance to distortion arising from the above-mentioned causes.

There is now finally to discuss several points arising out of the method adopted by Diefenthaler in obtaining the pearlitic structure. The writer approaches this portion of the subject with considerable diffidence. As already pointed out so much essential data is lacking, and what experimental data the writer has found available leaves one in doubt as to whether the method of casting into heated moulds is really necessary.

Formation of Pearlite.

The pearlite constituent is formed in the pure iron carbon alloys from the solid solution known as austenite, by the resolution of the austenite into a two component constituent—pearlite—at the temperature of the arrest on the cooling curve known as Ar_3—about 760 deg. C. The amount of pearlite formed depends in some manner on the austenite solid solution, and it is easy to see that there are several important differences between the formation of pearlite in cast iron and steel. In steels below 0.9 per cent. carbon the amount of pearlite formed depends upon the amount of combined carbon present or the concentration of the austenite solid solution. Above 0.9 per cent. car-

* J. E. Hurst, "Engineering," July 4, 1919.

bon the amount of pearlite formed is a constant amount, in fact all the matrix of the pure alloys will be pearlite unless the solid solution undergoes any changes in cooling down prior to reaching the temperature of the Ar, point, which reduces its concentration to a value below 0.9 per cent. This is what actually happens in commercial cast iron. Long enough before the temperature of the Ar, point is reached, in fact at temperatures round about the final solidification temperature, graphite is formed. It does not matter for present purposes how this graphite is formed. It is sufficient to note that if the carbon exists in the cast iron as free graphite at these temperatures it cannot exist in the solid solution. Therefore the solid solution is reduced in concentration according to the amount of graphite formed, and according to the reduction in concentration of the solid solution so the amount of pearlite is affected later on at the temperature of resolution of the solid solution. This at once leads us to the important conclusion that the amount of pearlite in cast iron is governed by the conditions of the formation of the graphite at the range of temperatures at which the graphite is formed, and that any attempt to control the amount of pearlite present is practically the same thing as controlling the amount of graphite present.

In commercial cast iron containing silicon a certain proportion of the graphite present is undoubtedly formed during that period of the cooling between the final solidification temperature and the temperature of the resolution of the solid solu-

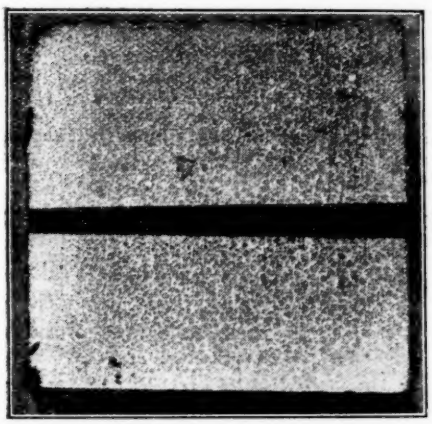

FIG. 5.—NETWORK STRUCTURE OF PHOSPHIDE CONSTITUENT MACROSCOPIC STRUCTURE.

tion. That is to say, after the principal proportion of the graphite has been formed. The extent of this, which has been called the secondary graphite formation, is governed by the rate of cooling and the amount of silicon present. In low silicon irons with the ordinary rates of cooling in castings the extent of this secondary formation is not large unless the rate of cooling during this range is so slow as to almost be the equivalent of an annealing process. Even in thick castings in which the structure of the central mass is usually one of free ferrite and graphite, the whole of the graphite is principally of the primary formation, and the ferrite graphite structures are the result of the rate of cooling being sufficiently slow at the tempeatures round about the solidification point as to result in practically the whole of the graphite being precipitated at this temperature. The writer is of the opinion that the so-called secondary graphite is not so common as is frequently imagined, which is somewhat contrary to the general views held on this matter. Evidence of the correctness of the writer's view is to be had from the microphotograph Figs. 1 and 2, which show the general appearance of primary and secondary graphite. The secondary graphite in this example has been artificially produced by heat treating the sample. It has the distinct appearance of the free carbon in malleable castings, and is of a type very rarely met with in slow cooled samples from the molten state, an example of which is to be found in Fig. 3. This is a microphotograph of a specimen taken from the centre of a large feeder head on a vertically cast hydraulic ram. This photograph has been kindly loaned to the writer by Mr. J. A. Gardner, chief metallurgist to Glenfield & Kennedy, Limited, Kilmarnock. No evidence of secondary graphite is to be seen but on the contrary huge plates of primary graphite embedded in crystals of ferrite. It will also be noticed that the composition of the cast iron in this particular case is fairly high in silicon.

Border Line Compositions.

In an iron of a given chemical composition it is a well known fact that the rate of cooling is a vital feature in determining the extent of the graphite formation. The extent of the graphite formation, however, we know from experiment is not a linear function of the rate of cooling over all possible rates of cooling. In any event, other things being equal, there must be a rate of cooling below or above which graphite is or is not formed. In a like manner, other things being equal, and with cast irons of the chemical compositions met with in ordinary practice, it is possible to conceive of certain chemical compositions which would invariably be white irons and others which would be invariably grey irons under the particular conditions. This being the case, there must be an intermediate series of chemical composition which with small variations in the other conditions—principally the rate of cooling—would be either white or grey according to the direction of variation of these conditions. There are, of course, a large number of possible chemical compositions falling within this intermediate zone according to whether these elements, which are known to exert an influence on graphitisation, are considered singly or combined. In this connection something of the order of a critical percentage of certain elements, other features of the chemical composition being equal, and for a given rate of cooling, has long been suspected above or below that which graphitisation is or is not effected.

Traces of such a point are to be found in the standard investigations on the influence of silicon on cast iron. In the classical experiments of Turner* on the influence of silicon, we do not find that the graphite contents gradually increase with increasing silicon content, but we pass a point where a comparatively small increase in silicon content brings about a large increase in the graphite formed. In a like manner in the experiments of Hatfield†—in which quite a lot of care was taken to ensure that all the conditions of casting were comparable. These experiments were conducted on thinner bars (viz., 1 in. × ⅝ in.) than in Turner's experiments and a similar point was noticed. In a second series of similar experiments conducted at higher casting temperatures than the former the existence of a similar point was confirmed. A further series of experiments undertaken by Haigh and Turner‡ show a somewhat similar result.

The figures illustrating this point are abstracted and tabulated below from the various experiments, and show sufficient evidence of the existence of a critical composition, in these cases a percentage of silicon, at which there is a rapid formation of graphite. This percentage of silicon lies between 1.0 and 2.0 per cent. for the particular compositions, and mean rates of cooling conditions in the above experiments.

There are certain further observations which can be made from the above experiments, which are worthy of notice. The first one which was pointed out by Hatfield in the original experiments is that with a higher casting temperature, the critical silicon percentage has a higher value. This is tantamount to saying that with a higher casting temperature there is a tendency for the prevention of graphite formation and the irons would consequently be harder. This was further demonstrated by Hatfield, who showed that in an iron containing 1.10 per cent. silicon the bar cast at a temperature 180 deg. C. higher than the other was mottled white in fracture, whilst the lower casting temperature bar was found to be grey.

The second point to be noticed is that the extent of graphitisation is slightly influenced in these experiments by the total carbon contents, for it will be noticed that with a total carbon content of 2.53 per cent., silicon 1.72 per cent. is neces-

* Journal Chem. Soc., Vols. XLVII and XLIX.
† J. I. S. I., No. 2, 1906.
‡ J. I. S. I., No. 2, 1910.

sary to bring about approximately the same condition as 1.96 per cent. brings about in Turner's experiments. It is perhaps hardly fair to compare these experiments in this fashion, and this has been done here only to show that these experiments confirm the general opinion more or less.

It will be quite clear from the definition of pearlitic cast iron that it is intended to belong to the class of irons which have been described as borderline compositions, and we may expect that this being the case it would be extremely sensitive to the effect of the rate of cooling.

Grain Size.

The importance of grain size has only been partially dealt with in the consideration of the strength properties of cast iron. The importance of the graphite size has been fully realised, but it does not appear to be clear that the grain size, apart from the graphite, is of some importance, and is not necessarily in accordance with the graphite size. It appears to be generally imagined that the free graphite in cast iron exists round the crystal boundaries, and a little reflection will show at once that this cannot be strictly correct. If it is assumed that the primary graphite is formed over a range of temperature round about the solidus line, probably partly above and partly below, we at once appreciate that the crystalline structure of the alloy has already been established and the graphite formation is actually an internal change in the crystal grain. It may, however, take place to a sufficiently large extent to break up the crystal grain structure, and in this manner it may be said that the graphite exists round some crystal boundaries. In this case the graphite is existing strictly at the crystal boundaries of its own making due to the rupture of the various crystals in which it is formed. This is clearly shown in Fig. 3 already referred to in which is found the crystals of ferrite with large graphite plates passing through them.

In the majority of commercial samples of cast iron where the structure is a complex mixture of numerous constituents, it has not yet been found possible to show up the crystal boundaries under the microscope. In this connection it is the author's opinion that the now well-known network structure, the significance of which in the strength properties of cast iron was first shown by Cook and Hailstone, is synonymous with the grain size. The actual cause of this network structure of the phosphide constituent has never been satisfactorily explained before. Two illustrations of the network structure are given in Figs. 4 and 5. Fig. 5 is particularly interesting in revealing the segregation of the last to solidify mother liquor in a cast iron containing an extremely small quantity of phosphorus.

The influence of crystal boundaries on the strength properties of metals is well known, and it will be readily appreciated that in cast iron the influence of the crystal boundaries will become more and more predominant as the size and consequently the influence of the graphite is decreased.

The importance of the grain size as independent from the graphite size is not sufficiently well realised, and it is quite an easy state of affairs to imagine cast irons having the same graphite size and different grain sizes and *vice versa*. We have here another peg on which to hang explanations for those frequent anomalies in strength properties which are the bone of contention of many foundrymen.

The grain size is determined at an earlier period of the cooling of cast iron, and within limits is seriously altered by the rate of cooling conditions.

Rate of Cooling.

The object of discussing these features—the composition, structure and the grain size—is to show that they are well known to be fundamentally controlled by the rate of cooling conditions.

The feature of the Lang pearlitic cast iron process so far as we know it is the use of heated moulds. This feature has the direct result of altering the rate of cooling conditions from those under which cast iron cools when normally cast into sand moulds.

Another difficulty which again presents itself in discussing this aspect of the subject is the lack of any specified casting temperature data. It is impossible to ensure comparable rate of cooling conditions unless this temperature is specified. This is equally as important as the specification of the initial temperature of the mould.

Broadly speaking, if the casting temperatures are maintained as in normal foundry practice, we should expect the provision of heated moulds would retard the mean rate of cooling, and it would appear that Diefenthaler's object of using heated moulds is to secure conditions such that when casting compositions of the borderline type, it is primarily certain that they are going to be on the soft grey and machinable side of the borderline. This appears to be the most important feature of the process.

Table III.

Turner's Experiments. J.C.S.				Hatfield. Series "A"				Hatfield. Series "B"				Haigh & Turner.			
Tot. C.	CC.	Gr.	Si.	Tot. C.	CC.	Gr.	Si.	Tot. C.	CC.	Gr.	Si.	Tot. C.	CC.	Gr.	Si.
1.98	1.60	0.38	0.19	2.9	—	trace	0.66	3.00	3.00	trace	1.51	2.71	2.55	0.16	0.03
2.00	1.90	0.10	0.45	2.9	—	,,	0.88	3.00	3.00	,,	1.71	2.61	2.44	0.17	0.23
2.09	1.85	0.24	0.96	2.9	—	,,	0.99	3.00	2.90	0.10	1.73	2.95	2.82	0.13	0.66
2.21	1.71	0.50	1.37	3.0	—	,,	1.10	3.02	2.91	0.11	1.80	2.56	2.33	0.23	0.97
2.18	0.56	1.62	1.96	2.98	2.70	0.28	1.43	2.98	1.78	1.20	1.95	2.70	1.38	1.32	1.19
—	*	—	—	2.95	2.30	0.65	1.68	2.97	1.50	1.47	1.97	2.48	1.19	1.29	1.50
—	—	—	—	2.53	0.6	2.47	1.72	3.12	0.62	2.50	2.05	2.47	0.97	1.50	1.95

* In view of the later work of Haigh and Turner, the degraphitisation in this case may have been due to the increase in manganese content which increased from 0.26 to 0.60 per cent. between the third and the fifth samples.

Conclusions.

In summing up these notes and considerations it must be borne in mind that the writer's knowledge of the subject is secured from the technical data which has appeared in the Press and which is so scanty as to prohibit any definite statements as to the merits or otherwise of the pearlitic casting process.

The merits of the process would have been demonstrated with more certainty if Professor Bauer had given us the comparative data on his samples before and after treatment by the pearlitic casting process.

In its conception the use of irons of borderline composition and utilising hot moulds to ensure a pearlitic structure, or at least a machinable structure, for a given thickness of casting attracts to the author as a method of obtaining better mechanical properties, particularly in those thin castings in which it is necessary to use a higher silicon content to ensure machinability.

The influence of the pearlitic structure in itself is considerably overstressed, and it is undoubtedly due to the size, arrangement and distribution of the graphite and the crystals that the strength properties are due. The pearlitic structure in itself is undoubtedly a distinct advantage from the point of view of resistance to wear and to certain distortion under heat influences.

Finally, there is no doubt that pearlitic cast iron and the pearlitic casting process, in so far as it complies with the fundamental definition, is a subject worthy of the serious consideration of foundrymen. It is to be hoped that the authorities connected with this material will take an early opportunity of putting before us the plain, simple information necessary to convince us that their actual practice is in accordance with the terms of their definition and to demonstrate conclusively the superior properties which they claim for pearlitic cast iron.

Departmental Costs in the Foundry.*

By Howell B. May, Shreveport, La.

The purpose of departmental foundry costs is to provide detailed information as to the separate components of cost which have entered into a product. General accounting shows the total profit or loss of the business as a whole; engineering or departmental costs show the profit or loss on each unit, whether the unit be the job, contract, line of product or operating department.

With departmental costs profitable and non-profitable lines are clearly recognised, thus enabling the sales department to choose the line for their greatest effort: non-profitable lines, it is true, are not always abandoned. They may be continued:—(1) For their advertising value; (2) for the purpose of completing a line; (3) for the accommodation of substantial customers of the profitable lines; and (4) for maintaining production in slack seasons due to the fact that part of the overhead is fixed and continues regardless of the change in the volume of production.

If a non-profitable line is continued for these or any other reasons, it is of the greatest importance for the foundryman to know just how far he can maintain the policy.

Departmental costs aid all divisions of a business; sales, financial and operating departments. The sales department, in addition to knowing the profitable and non-profitable lines, is enabled to fix selling prices and to plan sales campaigns intelligently through up-to-date information of current and unusual costs.

Data More Important for Future than Past.

The financial department should consider cost data more than history. This data, through careful analysis, may be used in estimating present and future capital requirements. Detailed costs are not alone necessary for the establishment of selling prices, but are of far more importance as an aid to managerial control. They are of great assistance in the elimination of wastes of materials and labour. They also show whether or not operating capacities are being utilised efficiently. The executive, through detailed records, is enabled to determine the departments where expenses are high; to determine the cause of such extra expense; and to take such steps as may be necessary to overcome or reduce them. Detailed costs furnish a means for the careful study of operations, enabling the department foreman to make improvements and bring about reductions in the cost of operation. A lot of figures bunched into one total are of no use to an operating department, even though they represent the correct cost of a product. To be of value the cost of each component part or process must be known; then, and then only, can a constructive analysis be made.

Properly organised costs not only give conclusions with reference to past performance, but so present the elements of cost as to enable the executive to establish a control over the business from the anticipative standpoint. Labour is made more efficient through the proper planning, scheduling and supervision afforded by production control, an essential requisite if costs are to produce the greatest returns. Cost control gives a money check upon the progress of these methods in intimate contact with the doing of the work. Material likewise is subject to a similar control, and this part of costs should indicate any unusual conditions, losses or wastes.

Overhead is the most difficult problem in the establishment of cost control, and although by far the largest single item of cost, it is usually the least understood and the least controlled. If, however, it is handled from a logical standpoint based on practical experience and a thorough analysis of operating conditions, overhead can also be subject to a very accurate and immediate display of timely facts. It is really surprising how far burden or indirect costs can be controlled when accurate analysis is at hand and when a check upon those responsible is kept.

Adequate cost control will furnish the following:—(1) Timely and accurate knowledge of the work in process as to its cost, with a monthly analysis, thus preventing possible serious conditions from going unknown until too late to remedy them; (2) timely and accurate knowledge of the cost of each contract or job as it progresses; (3) monthly profit or loss statements and inventory balances; (4) indications of leaks and dangers as well as good points of management and policies; (5) a basis for the establishment of equitable piece or bonus rates; (6) a basis for true, accurate and quick estimates on new work; (7) display and running comparisons of actual overhead and expense in each department; and (8) display of the value of inventory accounts, and monthly comparisons with work completed.

For the successful operation of any business it is necessary to provide for main and subsidiary departments. This departmentalisation is also indispensable to the successful application of foundry costs. In fact, organisation, production control, management and foundry costs are so closely related that it is almost impossible to separate them. The cost engineer must be familiar with the principles of management and good organisation as well as the principles and practices of cost accounting, and, what is more important, he must know how to correlate or tie up the cost work with management.

The assignment of definite responsibility is necessary both from the point of view of management and the cost engineer. The definite assignment of physical and financial responsibility constitutes the essential conception of departmentalisation. Coupled with the definite assignment of responsibility is the necessity of providing the means of reflecting the results of this responsibility in figures.

The character of each department influences in a large measure the selection of a suitable cost plan. Another important factor to consider is the nature of the operations for which each department head is responsible. It is often found necessary to have two different overheads in the same department, for example, machine and floor moulding. The one has to carry power and maintenance charges which do not enter into the other.

In addition to the regular expense departments which must be absorbed in the producing departments, it is frequently necessary to provide for subsidiary departments or cost centres. For example, the process of heat treating may not warrant a physical department for that work alone; however, it must be treated as a cost department in order to properly collect and distribute the cost to the product.

Some of the fallacies of the average cost plan are burden and expense incorrectly distributed; producing and expense departments improperly segregated; overhead and expense items inadequately analysed; and costs not tied up and made an essential part of management.

The analysis of departments as to responsibility and operations necessary for cost work can be used to formulate definite plans of organisation. Exactly the same records required for adequate costs can be used to plan and schedule operations of machines, work places and departments. These same records may also be used for the establishment of equitable bonus rates.

Cost work, organisation and production control can be carried on at the same time. The cost work may be made in conjunction with a revision of the general accounting system or entirely independent of it, but should at the proper time be interconnected with the general accounting through a series of control accounts which take the total figures at the end of each month or costing period and by means of the regular journal or voucher entries make them a part of the general accounting.

In order for a cost plan to be properly devised a careful analysis of each department must be made to determine the correct basis on which to

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distribute the overhead and expense items ; to determine the accounts necessary to supply adequate information and analysis; and to determine the proper organisation for carrying on the work. The essential point is to have the cost plan designed to fit the special needs of the plant.

Straight Tonnage.

It is unfortunate that many foundries still use the straight tonnage or average flat cost per pound of all castings produced. This plan is fundamentally unsound except where one product is made, or where all castings have practically the same weight, the same moulding and core time, the same degree of intricacy, and the same percentage of loss. Foundrymen know, however, that these conditions are rarely found on dissimilar castings, consequently the average flat cost per pound is applicable in very few foundries.

The inadequacy of the flat cost per pound has been demonstrated many times, not only for the purpose of establishing selling prices, but for managerial control. It is about as sensible for Henry Ford to average the cost of the Lincoln and Ford as for the foundryman to average his costs on dissimilar castings. Since the average flat cost per pound is fundamentally unsound it will not be discussed further.

Source of Cost Data.

In order that costs may be properly determined there are certain channels through which must flow a steady stream of information to the cost department.

A stock record should be kept of all raw materials and supplies. The cupola or furnace charge sheet serves as a requisition for pig-iron, scrap and all materials used in melting. For all other supplies a requisition should be used which shows the proper charge account and correct pricing of all material required. A set of charge accounts is necessary for all major divisions of indirect expense in each department. These charge accounts must be in such detail and must be analysed very carefully if the full managerial benefit is to be derived.

All materials and labour chargeable directly to a job should be accounted for on production orders which constitute the authority to do a given work, these entries being derived from time cards and requisitions. All labour, both direct and indirect, must be accounted for on time cards. An analysis of defective castings is an important record in connection with the managerial costs. Forms are simply the vehicles to convey information. The chief requisite is that they must be adequate and comprehensive.

Divisions of Foundry Costs.

The manufacture of castings involve a number of operations, each of which presents its own problem of cost treatment. The melting of metal is distinct from the succeeding operations. The moulding department has problems which are not found in other departments. The nature of the operations determine the cost divisions into which the foundry should be divided.

The following cost divisions usually cover the average foundry :—(1) Melting; (2) moulding overhead and machine hour rates; (3) core overhead; (4) annealing cost; (5) cleaning and finishing cost; (6) sand, pattern and flask cost; (7) general expenses; and (8) standard rates.

Melting Costs.

In setting up the charge accounts for melting department a distinction must be clearly made as to where the melting department leaves off and where the moulding department begins.

In some foundries the pouring gang is part of the moulding organisation. The maintenance of ladles usually falls under the melting department. As a general rule, the conversion cost will cease upon delivery of metal at the spout in grey iron and non-ferrous foundries, while in steel plants the conversion cost ends with the delivery of metal to the moulds. In malleable plants the practice is the same as grey iron, although some malleable plants have developed a practice similar to the steel foundries.

Another important consideration in the melting department is to have the charge accounts for metals so separated that fluctuations in market prices will be reflected in the materials section. These items cannot be controlled by the melting department, consequently the conversion cost is the real gauge of this department. Should protracted contracts for castings be made, it is evident that fluctuations in the market prices will materially affect the prices charged for metal on these contracts if charges are made on basis of average cost of metal. However, if metal is purchased to cover the requirements of the contract at prices prevailing when contract was made, a separate stock record should be kept of this specially-bought metal.

Should no metal be purchased for the protracted contracts, and a sharp increase in market prices is brought about, there is nothing else to do but take the loss, if found necessary to buy at the higher price. It is still the practice in many foundries to calculate the conversion cost on the basis of good castings produced. No attention being paid to the fact that one casting will have several times its own weight in gates and risers, and, in addition, will have a high waster loss of 50 to 60 per cent., while another casting will weigh ten times as much as the gates and risers and will have a loss due to wasters of less than 1 per cent. In order to secure accurate costs under these conditions, it is necessary to base the conversion costs on the pounds of metal poured, charging all of the conversion cost to the castings in question.

The defective castings and recoverable gates and risers should be credited back to the job at scrap value only. This crediting back is not so difficult as it may seem. The wasters come from the inspection reports—while sprue ratios may be established which will facilitate the crediting of gates and risers.

Moulding Overhead and Machine Rates.

The moulding department is concerned with individual patterns, consequently the direct labour hour is the unit upon which to base the distribution of overheads. In the final analysis it is time that is being sold, therefore, it is only logical that, wherever possible, time should be the unit upon which to distribute departmental overheads. Many foundries still use the amount of money paid for direct labour as the basis of distribution of overheads.

The fallacy of this practice is apparent in the following examples: If a job can be done in one hour by a 1s. man, and it takes a 2s. man the same time, double the overhead has been placed on the 2s. man. This is manifestly unfair, since he has not used any more power, heat and light, depreciated equipment to any greater extent, nor absorbed a bit more taxes, insurance and other fixed expense items than the 1s. man. In order more closely to allocate costs, especially on jobs requiring the use of moulding machines, a machine-hour rate should be established which includes :—(1) Depreciation; (2) maintenance; and (3) power.

Labour of operators should not be included in the machine rate. All labour in connection with the job should take the regular departmental overhead rate and charges made in addition for use of machines based on machine-hour rates.

Core Overheads.

All indirect expense in connection with the making of cores should be charged to the core overhead account and this distributed to the job on the basis of direct-labour-hours. This includes sand, binders and core oven expense. Where machines are used for making cores, a machine-hour-rate should be established as in the moulding department.

Annealing Costs.

The item of annealing cost only applies to steel and malleable foundries. In the malleable foundry the annealing cost is very important, because of the length of time required for the operation. Charge-accounts should be set up which show the various elements entering into the costs, such as packing, charging furnaces, unloading, furnace men and other contributing operations. If both annealing pots and muffle furnaces be used the

costs for each process should be segregated. The cost is then distributed on the weight basis.

Annealing in the steel foundry does not present a very difficult cost problem. Here it is merely a matter of loading the castings on a car or in a pit and removing them. However, the elements of cost should be known, so that economies may be effected. The cost is distributed on the basis of weight annealed. Any other heat-treating operations should be handled in the same manner as the annealing.

Cleaning and Finishing Costs.

The time required for cutting off gates and risers and other grinding and cleaning operations in grey iron, malleable and non-ferrous foundries is usually so small that it is impracticable to charge the direct labour to the jobs. In the steel foundry, however, a very much different condition is encountered. Where it is practicable to do so, the cleaning and finishing direct-labour cost should be determined and the overhead distributed on the basis of direct-labour-hours. A plan which has been tested out thoroughly in a number of plants and found to give a very close approximation is to assemble the entire cost, both direct and indirect, of all cleaning and finishing operations, and distribute this cost on the basis of the combined moulding and core direct-labour-hours. Cored castings require a greater amount of effort to clean than do solid castings. By using the combined moulding and core direct-labour-hours the cleaning of the outside is in proportion to the labour required to make the mould, while the cleaning of the inside is proportioned to the direct labour required to make the cores. This method is manifestly much better than the tonnage basis used by some foundries.

The tonnage basis is unfair, because solid castings weigh more than cored castings of the same volume, and consequently absorb a greater cleaning cost, although it can be readily seen that more cleaning is necessary on the cored castings.

Sand, Pattern and Flask Costs.

In the smaller foundries sand, pattern maintenance and flask cost on standard jobs is absorbed into the regular moulding overhead. Pattern and flask expenses are charged directly to special jobs in the jobbing foundry. In the larger foundries, especially steel, where a great volume of sand is consumed and where mechanical equipment is required for conditioning and handling, it has been found necessary to keep a separate cost. As the sand used is in almost direct proportion to the tonnage of metal poured, this, then, should be the basis for distribution of the sand cost. In the specialty foundry the maintenance of patterns for each product is charged directly to the line. Any flasks specially built for a job should be charged to that job. The cost of metal flasks interchangeable for use as standard equipment should be set up in a flask account, and this cost distributed on a basis of good castings.

General Expenses.

Local conditions govern entirely the selection of charge accounts to cover contributing departments. Whether the foundry is a separate unit or a part of a larger plant also affects the selection of charge accounts. Care should be taken to group all of these expense departments so that proper managerial control can be exercised.

The wages department, the cost department, and similar departments serve all divisions of the foundry, and the cost of same should be distributed into those divisions. The best basis for distributing their expenses is through the total labour-hours, both direct and indirect, in each department. If a power plant is maintained the cost of operation should be analysed very closely. Power is charged to departments on the basis of consumption. Transport expense is charged on basis of service to each department. It is essential that a practical basis be determined for the distribution of expense items to the departmental overheads, and finally to the cost of the product.

Standard Rates.

The cost of any one month can hardly be accepted as a criterion of the efficiency of a department. One month the repairs may be unusually high, occasioned by the relining of a cupola or the rebuilding of the open hearth or air furnace and by other extraordinary expenses which must be absorbed by the product. Experience has shown that an average of not less than six months should be used. A year's average will reflect a much truer condition. In order to utilise the average cost to facilitate the work, predetermined or standard rates are made use of. These rates are established after careful analysis of the costs in each department over a period sufficient to reflect a true or normal condition.

The actual rates are determined each month, and are compared with the standard rates. At the end of the next six months' period another adjustment in rates is made. Should a wage increase or decrease be made during the interval, an adjustment may be made to take care of it. A small balance of under- or over-absorbed overhead will be determined each month. This may be carried directly to the profit or loss account at the closing period.

Standard rates may be determined and used for the following:—Conversion cost; metal cost; moulding overhead; machine-hour rates; core overhead; annealing cost; cleaning and finishing cost; flask cost; sand cost; pattern cost.

Causes of Failures of Cost Systems.

Good cost plans have failed due to the lack of authority to secure the co-operation within the organisation during the installation period, and after installation, when the cost man has left, through opponents of the plan. Again they have failed because of meddlesome clerks and minor officials making changes from time to time without determining just what effect these changes may have on the cost plan as a whole or the relation to other departments. When some important link has been destroyed in a cost plan it loses its effectiveness.

The design and installation of a cost plan should be entrusted to a man who has a practical knowledge of organisation, production control, management, shop operations, and material handling, as well as a knowledge of the principles of cost accounting. He should be given the authority and place in the organisation which will enable him to carry through to a successful conclusion the work undertaken. When once a routine has been established as standard practice, no change should be made in that routine without the consent of an executive whose duty would be to analyse what effect the change would bring about in other phases of the work.

A cost plan to be of the greatest value must be designed from the engineer's point of view rather than from the accountant's. There is no question of the value of the accountant where the general and financial books are concerned, but he is not so much interested in detailed overhead and expense statements as the manager and department superintendents, upon whom rests the responsibility for operating at a minimum expense. Furthermore, the average accountant does not have the years of practical shop experience which is so essential in making a correct analysis of operating conditions, a prime requisite in the design of a cost plan.

The Midland Motor Cylinder Company, Limited, of Dartmouth Road Foundries, Smethwick, Birmingham, have now completed the lay-out of their Coventry foundry on the most up-to-date lines and with most modern equipment. It is the intention of that Company to effect similar improvements at their Smethwick foundries, and work there will be commenced almost immediately; the alterations will naturally take some months to complete, but no expense is being spared in using this opportunity to make their Smethwick foundries similar to their Coventry foundries—the most modern and up-to-date in the Midlands, replete with every approved labour-saving device and innovation which makes for speed and efficiency. The work in connection with these alterations has been carried out by the Pneulec Machine Company, Limited, of Mafeking Road, Smethwick, the well-known foundry equipment firm.

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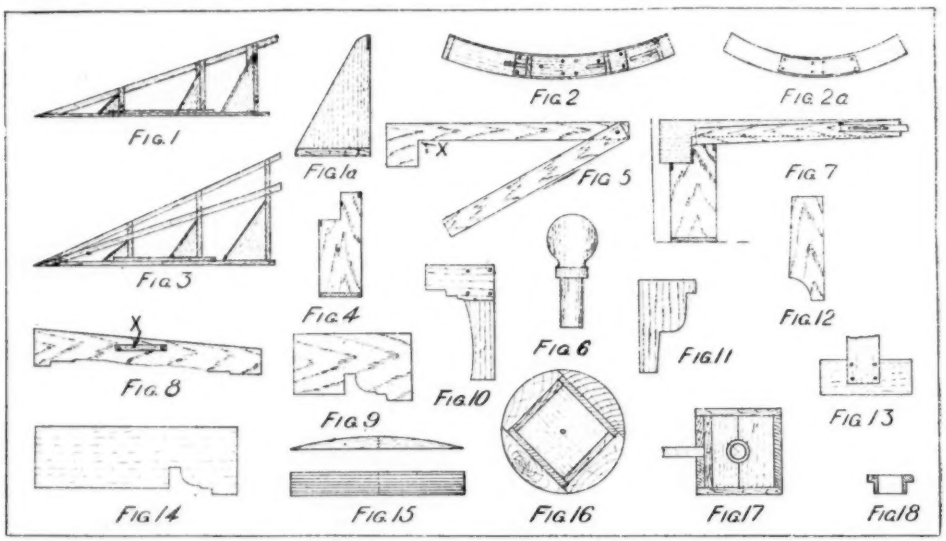
Making Propellers.—IV.

By Ben Shaw and James Edgar.

There is such a considerable difference in the procedure necessary when sweeping up propellers in loam from the construction of solid patterns in wood, that it is not uncommon to find pattern-makers who are able to cope with the one class of work, yet have had no practical experience of the other class, and who indeed, owing to their lack of theoretical knowledge, are quite at a loss as to how to begin. This also applies to the casting of the work in the foundry. A moulder may have made many small propellers in green or dry sand from solid patterns, yet be quite at a loss as to how to proceed in constructing a loam mould, either for a single blade or for a full three or four blade propeller. This is largely due to the fact that a moulder usually specialises in one class of moulding. It is surprising how satisfactorily some pattern-makers can carry through the work required for a loam job, even if they have only the haziest notion of the theory of propeller design. At the same time the work is much better if done by a man who has technical knowledge.

When a propelier drawing is received from the drawing office it is usually given to a charge hand, who specialises on the work. His first procedure is to set down a section of the boss across its centre line, and he sometimes also includes on this view a section of the blade. On the same board he outlines the base board or board which sweeps up the bed on which the outside race rests while the mould is being swept.



Construction of Various Kinds of Races.

Figs. 1, 1a, and 2 show elevation and plan views of a race for a propeller of uniform pitch. The base, if the propeller is one of very large diameter, may be one thickness of timber, although this is not really advisable because of the tendency of the timber to warp, and while it is not customary to paint or varnish propeller races, it is essential that well-seasoned timber should be used for their construction. While it is the general practice to make a wooden outer angle, a framed iron angle is sometimes riveted together for the purpose.

The length of the race is usually made about $\frac{1}{4}$th of the circumference. The radial base should be 5 or 6-in. wide at least, and may be either made of two lengths battened, as shown in the illustration Fig. 2a, or built in two thicknesses of timber. Several uprights are screwed to it, strong enough to sustain a strip of wood on which the sweeping board rests, about $\frac{3}{8}$-in. thick and 2 to 3 in. wide. When several propellers are required of the same diameter and pitch, it is good practice to make this strip of hoop iron instead of wood, unless a wheel runner is attached to the sweep, because there is a tendency for the edge to become worn in places, and the resultant casting, in such a case, would not have the pitch required.

Angles or races can be placed at any reasonable distance from the centre of the boss, providing the base of the angle is the circumference of the circle at which it is desired to place the angle away from the boss and the height of the perpendicular equal to the pitch required at the same distance from the centre. Although $\frac{1}{8}$th of the full angle is generally used, it is not binding, and ought to be determined entirely by the width of the blade. The main point is that, whenever one angle is made, an inner angle, if such is required, should be made in the same ratio. Also it may be pointed out that when inner and outer angles are made it is necessary to divide them into several equal parts, say 12, with the centres projected down perpendicularly to the base. The important thing is that both races should be divided exactly alike, which ensures a true bed when they are strickled over in the foundry. When only one angle is used this division is not necessary, but the centre should be marked on the base.

This thickness of the race base should be from 1 to $1\frac{1}{2}$ in., according to size, but rigidity should be the aim, and the inner radius ought to be about 4 to 6 in. beyond the tip of the propeller blade. The uprights, which are supported by brackets, as shown in Figs. 1 and 2, may be 2 in. thick. It is often convenient to place a solid block at the bottom end of the angle, which acts as a support for the angular strip. If care has been taken in the construction of a propeller angle it will rest without any rocking on a level surface after it is completed. It will be readily seen how easy it is to get the pitch in error to several inches if great care has not been taken.

The pattern-maker varies the pitch somewhat from the drawing supplied to him. Owing to contraction or drawing of the comparatively thin tip by the heavier section nearer the boss, it is necessary to make the pitch somewhat coarser than the finished casting is required to be, and it will be found to be a good general rule to increase it by 3 in. A propeller that is required to be 10 ft. pitch may be made 10 ft. 3 in., and when cast it will be approximately correct.

In some shops it is customary to sweep propeller beds with inner and outer angles, that is, one angle beyond the tip angle of the propeller, and the other angle of a radius which allows it to be placed close to the boss. In most cases now, however, a swinging board is used and the inner angle quite dispensed with. When an inner angle is used it is made of sheet iron, and a template is supplied by the pattern-maker to the blacksmith for this purpose.

Necessary Modifications.

The angle just described is, of course, only suitable for a propeller of uniform pitch, and modifications have to be made when the pitch is either axially or radially varying. When it is axially varying, two angles will be represented by the race, because part of the blade will be, say, 10 ft. pitch, while the other part may be 10 ft. 6 in. We shall not concern ourselves here with the reason for the adoption of a varying pitch, although it may be mentioned that not only are propellers made at the present day axially or radially varying respectively, or both axially and radially varying, but sometimes the blade is curved. When the pitch varies axially it will be essential to place an upright at that point where the change of angles occurs, and this upright would have to be sufficiently thick to support the ends at the junction of the two strips, which would then be necessary to give the proper guide for the sweeping board. With a radially varying propeller, in which the pitch is coarser at the tip than the root, it is necessary either to have two races or to make one race, an outer race, so that it acts as a bearance for two boards, one of which is merely a guide for the inner pitch, and the other for the outer pitch. Propellers are occasionally made with a radially varying pitch of a different kind. The pitch may be uniform up to a diameter midway between the boss and the propeller pitch, and it may then change and be uniform for the remainder of the blade. For a propeller of this kind it is necessary to have three races, the inner and middle races being of iron, and the outer one constructed of wood, or the three may be constructed in iron.

A more common method, when a pitch varies radially, is to make two templates, inner and outer. When corresponding lines have been marked on each of these templates, the moulder sweeps his bed between these points with a straight edged strickle.

It is often contended, and with some truth, that the inner template is objectionable, because of the difficulty in setting it accurately. In foundries where many propellers are made of the same design, it is fairly common practice to use the same inner template many times, and alter the pitch by screwing a strip of wood to the top edge. Even with outer templates made of wood this same practice can be adopted, although there are times when an alteration to a template may actually take longer to effect than the construction of a new one.

It is possible, and really simpler, to strike the bed of a radially varying propeller blade with one template. Fig. 3 is an elevation of a suitable template, and Fig. 4 a sectional view of the same. As in the case of the race already described, the height of the tallest upright is in ratio to the length of the base, that is, if the base is $\frac{1}{6}$th of the circumference, the height of the template will be $\frac{1}{6}$th of the pitch.

In some foundries it is the practice to sweep a bed on which the race rests, a mark being made by the board, and the template then weighted when in position. A better practice is, perhaps, to sweep a check on the bed which locates the exact position of the race. When the moulder is setting the race on the bed, all he has to do is to get the centre of the race in line with the centre marked on the bed, the check fixing the radius easily. The uprights have to be shaped as shown in the sectional view, Fig. 4, and in the front elevation, Fig. 3. The outer edge of the template is made to the pitch at the boss, while the inner side is made to the pitch at the tips of the blades.

A good runner for a strickle is made by screwing a strip of hoop iron or hardwood to the uprights as already described.

Sweeping the Bed.

Sweeping the bed is done by means of two boards, one being fixed to the spindle and the other being pinned to it near the centre. The fixed board is cut back at the outside edge like X, Fig. 5. When one of the two boards is resting on the top of the race, their under edges are in line. It is advisable, when making the fixed board, to plane the top edge in order that a level can be used when setting it. A pin should be turned similar to that shown in Fig. 6, with a knob handle for holding a loose board in position. When the moulder has a fixed board fast to the spindle he pulls the two boards down together as he lays on the loam.

The angle of the loose board to the axis varies at every position. The fixed board, as it descends the bed, immediately leaves the inner edge of the race, and when it reaches the foot of the race the distance between it and the race will be the same as the distance between the outer and inner edges at the top of the template. Fig. 7 shows the race and the two boards in position when sweeping the mould surface.

Various Boards Necessary.

The bearance board for the race is the first board that the moulder uses. A bearance board is shown on Fig. 8, and to avoid the necessity for it being inconveniently wide, it is made of approximately a parallel width and a special strip is screwed to it which, when the board is correctly adjusted, is exactly parallel with the level surface that has to be swept. Even when the strickle has been carefully fitted into a special spindle box, which will be described shortly, it is advisable, because of the length of the board in relation to the depth of the box, to test it carefully with a spirit level. The various boards should be made of timber at least $1\frac{1}{4}$ in. thick. The board, Fig. 8, sweeps a bearance about 8 or 9 in. wide for the outer race, and it also sweeps a bearance for a wood boss and print. It is common practice, however, with all propellers that are of medium size and over, to make a loam pattern for the boss which is swept in position.

We shall proceed now to a description of the various boards necessary for making the boss and the boss core. Four boards may be made, the first being called the "cup board." The illustration Fig. 9 (which shows the cup board), would be made to sweep the diameter at which the inside angle would be set. It will be noted that a print is swept out with this board for the centre core, and that the "cup" is only to the centre of the bottom radius, or thereabouts. It is usually customary to make the board to the centre line, but when the foundry is adjacent to the pattern-shop and the exact diameter of the spindle that will be used is known, it can be made exact before being sent to the foundry. The second board required, which may be called the "boss board," is made to fit the boss from the joint which is made by the cup board.

Attention may be drawn to the fact that when these two boards are placed one on top of the other, the outer contour of the boss is obtained, thus when the boss board rests on the cup swept by the cup board in the foundry, the loam pattern can be formed with prints on top and bottom for a centre core.

The core may be swept on a horizontal spindle or about a vertical spindle. For the latter method a core-box board is supplied and a top core board, which completes the full shape of the core. The core-box board should be made to fit against a spindle. Fig. 13 shows the alternative board for sweeping the outer bearance to Fig. 8. There are several ways in which the outer bearance may be swept, sometimes, for instance, as illustrated by Fig. 14, the cup board is extended to the top diameter and cup and bearance are swept at one operation.

Rapid Production of Propellers.

When a propeller is not required to be made at short notice, one or two men may make all the tackle necessary, and they will also follow the job into the foundry and attend upon the moulders until the casting has been poured. If, however, as in repair shops, a propeller is required urgently, while one man is making a race, another man may be employed making the sweep boards. When the race and boards have gone to the foundry, the pattern-maker can give his attention to the tackle that is required to form the loam pattern on the swept bed. For instance, a set of templates for the thickness of the blades have to be made. With high class work it is quite common to make a different set of section pieces for each blade, but for ordinary propeller work it is easily possible

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to use the one set for all the blades, especially if, as in the case of three bladed propellers, only one blade can be proceeded with at a time; with four bladed propellers, the position is certainly somewhat different, because moulders may be working on opposite blades, and it is then necessary that each should have a set of section pieces. These section pieces are sometimes made of quarter-inch timber, but often they are made much thinner. The thickness on the centre line can be obtained from the section of the blade laid out on a workshop board, but it is common practice for the dimensions of the section pieces to be drawn on a blue print supplied. When several section pieces are wanted, instead of making each one separately either with or without a template, it is more satisfactory to plane the block of timber on three sides and finish to the shape of the section piece required. Lines are then gauged, as shown in Fig. 15, space being left for saw cuts, and the section pieces being an $\frac{1}{8}$-in., or even less, in thickness. This can only be effectively done on a very sharp dimension circular saw.

Making the Tip and Boss Fillet.

With regard to the tip of the blade, and the fillet at the boss, after the moulder has set the section pieces to the lines that have been marked by the sweeping board, the service of a blacksmith may be obtained to fit a strip of quarter iron to form the outer shape of the blades, or, alternatively, a solid tip piece may be made of timber and $\frac{1}{4}$-in. square timber strips pinned round the edges of the section pieces. The objection to wood for this strip is that new pieces have invariably to be made for each blade. The fillet may be left entirely to the moulder, or where a radius is given on the drawing a few section pieces may be cut which the moulder can fix between the bed and the boss and the spaces between these section pieces filled with loam.

Practice varies considerably, of course. In various shops for instance, and especially is this so when several propellers are required of the same diameter and pitch, a boss may be of timber instead of being swept in loam.

It is not always possible, of course, to make a solid parallel pattern for the boss without making a joint across its length, which gives the moulder additional labour, and to obviate this, a pattern is made with a boxed-up square centre and a diameter formed of sectional pieces screwed to this. These sectional pieces may be either fastened from the outside or, better still, the box centre may be so constructed that the top can be opened and the sectional pieces screwed from the inside. It is advisable to make the centre with a suitable taper. The moulder then draws this from the sand and the sectional pieces fall into the space that is left. This makes a very satisfactory pattern and the principle is one that can be adopted for other work than propellers.

In many foundries a loose arm is used, which is balanced by a weight suspended from a pulley at the top of the spindle, but it is sometimes convenient to make a box similar to Fig. 17, with brass bushes like Fig. 18, fitted into the top and bottom blades. This box may be 8 or 9 in. square and 9 to 12 in. deep. It is sometimes much larger than this. One advantage of the box is that the boards can be set to it in the pattern-shop and carefully marked in position, so that adjustment in the foundry is a simple matter. On the other hand, it is open to question whether it is more convenient for a moulder to work with a board which he has to lift to the top of the mould after each down sweep, or use a board that is balanced on a pulley, and which can consequently be raised much more easily. When a spindle box is used it must be of strong construction, and of well-seasoned timber, otherwise the board cannot be set.

With regard to the centre core, it is often convenient to sweep this on a horizontal spindle with one board instead of on a vertical spindle with cup and top boards.

Grids for Top Parts.

Much of the pattern-maker's work is in the foundry, and this cannot be very satisfactorily dealt with here, but will be gone into fully in a subsequent article dealing with the moulding of large propellers. It may be advisable, however, to describe a method of making grids for the top parts. In certain districts the grids are made of wrought iron, but in others they are partly wrought iron and partly cast iron. In the latter case three patterns are sometimes made, one for a cast bar close to the boss, another near the outside diameter of the blade, and another midway between. They have to be made to place; they certainly could be made in the pattern shop, the face of the blade being developed for the purpose, but it would be highly impractical to do so, and much more labour would be involved. They should be at least 2 in. thick, and the under side ought to be about 1 in. at least clear of the pattern face. The tops of these bars are usually made approximately level for convenience when making the copes. While the inner bar, because of its comparatively narrow surface, may be made of solid timber, the middle and outer boards have to be made of top and bottom rails joining them. The patterns are an exact model of the cast bars. The bottom grid must be fitted to the bed surface. This can best be done by getting the bars of an approximate shape, raising it on parallel blocks on the mould bed and then marking a line with hermaphrodites. Rectangular holes are cored in the top and bottom rails of these grids, and wrought-iron bars are wedged from the inner to the outer grids, the finished construction forming one large grid, covering almost the whole surface of the mould.

Book Review.

Die Elektrostahloefen. By E. Fr. Russ. Munich: R. Oldenbourg, Glückstrasse 8. (Price, in paper covers, 14 gold marks; bound, 15.50 gold marks.)

The author's present book is supposed to deal especially with electric furnaces for steel making, and seems to be based more or less on his previous treatise, "Die Elektro-Metallöfen," in which special attention was paid to copper melting and refining. The present volume claims to be a text and reference book for the steel expert, and, judging by the contents, the author tacitly assumes that the student or reader already knows all about steel making by other processes, and only requires information about electricity in general, and electric furnaces used in steel making in particular. He begins at the very beginning, and discusses the electric current, electric measurements, Ohm's law, magnetism, induction, Kirchhoff's law, alternating current and such elementary matter, and next turns to the various kinds of electric heating. Then follow descriptions of about two dozen types of electric furnaces and their varieties, some of which have perhaps never been tried, or most certainly have never been adopted to any great extent for making or refining steel. Oddly enough, the Stobie furnace has been altogether ignored, not to mention others. Moreover, the various kinds of furnaces are not dealt with according to their merit; thus, for instance, the Rennerfelt furnace has 28 pages allotted to it, the Héroult 32, while the Fiat furnace is dismissed with only 4 pages.

Next follows a useful section on electric-furnace accessories, etc., such as electrodes, fittings used in connection with same, and the manufacture of electrodes, but not a word about the Söderberg electrode. The rest of this section is devoted to descriptions of methods of regulating the feed of electrodes, to instruments for measuring temperature, water and electricity, to high-tension switches and current regulators, refractories for lining furnaces, and the lining and heating of induction furnaces. The book gives one the impression that the author has collected a large amount of information on his subject, but has not properly sifted his material, and has included a great deal of matter, the omission of which would have materially improved the book. For some kinds of furnaces the author has nothing but praise, but the student would have been grateful for having disadvantages also pointed out to him. There is no index of names or subjects, which renders the use of the book very troublesome and difficult.

Organisation and Practice in a Steel Foundry Finishing Department.*

By Charles W. Heywood, Chicago.

Of the three main departments of a steel foundry, namely, moulding, melting and finishing, the last is the only one whose working force is composed almost entirely of common or semi-skilled labour. Finishing department efficiency, therefore, depends to a large degree on skilful direction and management.

ORGANISATION.

The Gang System.

It is possible that in the very small foundry one man may be able to supervise directly all the details of his department, but for the average foundry it is necessary that the foreman delegate some of his functions to well-trained subordinates. In the writer's experience it has been found that the gang system produces the most satisfactory results from the standpoint of both output and costs.

Under such a system each gang works under a leader who is directly responsible to the department foreman. These leaders should be experts in the particular operations of which they are in charge. Their duties, besides ordinary supervision, may consist of instructing new operators, inspecting material for both defects and workmanship, and checking the output of the different operators, if working on a piece-work basis.

The routing of work under the gang plan is quite simple. If special instructions are necessary in the case of rush orders or material requiring special attention, the foreman issues his instructions to the leader of the first gang. As the work proceeds each gang leader in turn transmits these instructions to the leader of the next succeeding gang. In the case of special castings it may be necessary for the foreman to instruct each leader in the method of handling same.

Gang leaders should, in their own gang, hold the full prestige of the foreman. That is, the foreman should not interfere with the men in the different gangs except on the appeal of the workmen. He should give all his orders to the gang leader, thereby indicating to the men that their leader is acting with the foreman's authority, and is responsible for producing the work.

It is impossible for any foreman to give personal attention to every man in his department. With the gang system, however, the foreman need deal directly with only the five or six leaders who supervise the various gangs. This allows the foreman more time to devote to details such as the proper routing of work, experimenting, checking castings from new patterns as they come from the foundry, and a general inspection daily of castings from the foundry, so that irregularities may be reported to the foundry foreman.

The Pace Maker.

Where the gang system is not feasible another successful plan is to employ a pace maker. It is his duty to develop a best method of handling each new run of castings as it enters the shop, and by personal demonstration to instruct the men in carrying out the determined practice. Also, by actual performance, he establishes a definite time in which the various operations may be performed. From this trial the foreman, after considering the pace maker's ability with the average ability of the gang, may establish a suitable piece-work rate.

It is necessary, of course, that the pace maker be thoroughly experienced in all the finishing operations. He should be interested and willing, and should work to full co-operation with the foreman.

For setting piece-work rates or daily output either of the above methods, in the writer's opinion, is superior to the time-study system, since all determinations are standardised by an experienced operator. It is not possible to stand over a man with a stop watch and tell whether he is doing a fair amount of work or stalling, nor is it possible to determine a fair gang rate from such a test unless the performer's ability is accurately known.

Layout of Equipment.

While layout will depend largely on local conditions, the following scheme will be found very satisfactory for economical production. The floor space should be of sufficient size to hold a day's output from the foundry. The annealing furnaces should be arranged at right angles to this floor near one end; the sand blast at right angles near the opposite end followed in order by the acetylene torches and welding equipment, grinding machines, chipping benches, tumbling barrels, and, lastly, the benches for final inspection. In locating these different units care should be taken to place them in such a manner as to avoid all unnecessary carrying, laying down and picking up. Care must also be taken not to place them so close as to cause crowding. Some shops arrange benches along the route of small material in order to avoid picking up, and it is a very good system.

Lift trucks are very convenient and economical for moving castings, although of course the overhead crane is usually to be preferred. In laying out a finishing department the most important consideration is to keep the material moving forward all the time; it should never move backward.

If the finishing department is laid at right angles to the foundry there can be no disputes over crane preference, which otherwise are usually decided in favour of the foundry at the expense of chipping room efficiency.

Routing.

Routing work through the finishing department is one of the foreman's most difficult problems. The size and shape of castings, and the condition in which they come from the foundry, are all factors which affect the routing. At the same time the foreman must keep the different pattern numbers separate as much as possible, especially if he is behind the foundry output.

The following outline has been successfully carried out at the plant with which the writer is connected:—

(1) Fettling, sprue cutting and rough inspection; (2) annealing; (3) sand blasting; (4) flame cutting of large heads and gates, followed by further inspection. At this point such castings as require welding are sent to the welders, while castings which pass inspection go to the grinders. Small castings go to one battery of grinders, large ones to another. Castings of intricate design with deep curves and angles go to the emery wheels of large diameter, and castings of plain design, with straight surfaces, go to the smaller diameter wheels; (5) chipping; (6) final finish. At this point, in shops equipped with both tumbling barrels and sand blast, small castings are sent to the former and large castings and gears to the latter; (7) final inspection; and (8) despatching floor.

Material, except in most urgent cases, should never pass by an operation until finished. For instance, if for some reason the grinders are delayed while the chipping keeps to schedule the writer believes it would be preferable to send the chippers home rather than to chip the castings before grinding and then be obliged to send them back for grinding. Any procedure which upsets the routing will cause confusion and delay, and thereby increase the costs.

Operations.

Knocking Out.—The first consideration is the floor. A good floor can be made by laying, on a level sand foundation, steel plates 1½ in. thick, 2 ft. wide and 3 ft. long. These plates may be cast in open mould, from off-grade heats.

In breaking off heads and gates they should be nicked, especially at the corners. While this can

* A Paper presented to Milwaukee Meeting of the American Foundrymen's Association. The author is connected with the Burnside Steel Company.

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be done with sledge and cold set, an air-hammer is to be preferred. Heads and gates should be broken away from, and not toward, the edge of the casting. When heads and gates are of the same size or larger than the section to which they are attached, it is safer to use the acetylene torch. Boxes may be provided, convenient to the floggers, into which the broken heads and gates can be thrown as soon as they are broken off. Refuse sand should be cleaned off the floor daily.

Annealing.—Many plants consider it advisable to anneal after sand blasting, while some sand blast both before and after the anneal. We prefer to anneal before the blasting operation, as the scale formed during the anneal loosens considerable sand, and the scale itself is easily removed in blasting. The proper procedure will no doubt depend on the nature of the castings and the peeling qualities of the facing sand.

When a car-bottom furnace is used two sets of false bottoms may be provided. While one set is in the furnace the other can be loaded for the next charge. If the furnace is not of the car-bottom type it is very convenient to use a charging car similar to those used in rolling mills or on open-hearth furnaces.

Sand Blasting.

The size of the castings will determine the type of sand-blasting equipment. For medium and large size castings the table-room type is well adapted. Extra large castings will demand a room with car, while small castings, weighing 20 lbs. and under, can be handled very well in a sand-blast barrel.

In our experience the fastest and most economical abrasives are those that come in the natural state.

Two men, namely a blower and a labourer, are needed in each room. The labourer looks after the sand separator, elevator, etc., to prevent blockades; he also loads and unloads the castings.

In blowing the best results are obtained by holding the nozzle about 6 in. from the work, and at an angle of 45 deg. The mixture of sand and air is important; when correctly adjusted there is a light blue streak at the nozzle. The air pressure should not be less than 85 lbs. It is a waste of time and material to attempt the blowing of steel castings with 75 lbs. or less.

A nozzle made of mild steel gives very good results and can be made in the plant. The best nozzle is 2 in. or 3 in. long, with 5/16-in. hole. If using a very fine abrasive, a smaller hole is necessary.

The hose is an expensive part of the equipment, and wears out very rapidly near the tank end. By loosening the connection and giving the hose a quarter turn every second day the life of the hose will be more than doubled.

Grinding.

In grinding an important point is to run the wheels at a definite peripheral speed rather than at a uniform R.P.M. With the type of wheel employed by the writer best results are obtained with a peripheral speed of 6,500 ft. per min. To maintain the correct peripheral speed arrange different R.P.M. on the various machines and start the maximum diameter stone on the lowest R.P.M. machine. After wearing off about 4-in., transfer the stone to the next higher R.P.M. machine, and so on until it is worn down to about 8 in. or 10 in. diameter. By this method maximum service is obtained with very little discard. Of course, the ideal installation would have direct-driven machines with variable speed motors. All grinding stands should be of heavy design and placed on a good concrete foundation.

To increase the operator's output arrange some device which will give him a greater leverage. A simple arrangement is made by the use of a lever made of hard wood, about 2 in. sq. by 24 in. long. To this lever, at one end, is attached a short piece of chain by means of a ½ by 3-in. eyebolt. The chain in turn is secured to the grinding stand by a small hook in such a way that the length of the chain may be adjusted at will to suit castings of different size.

Chipping.

A bench 26 in. high, with blocks of wood nailed on in the form of jigs to hold the work, is very satisfactory for chipping small castings. Where there are long runs of the same castings it is better to use a permanent jig of iron or steel. A very good arrangement for castings running from 50 up to 1,500 lbs., is an empty oil barrel sawed off to about 24 in. Fasten this to the floor, bottom side down, with angle irons. Bolt a ½-in. by 2-in. ring around the top and fill with sand. This allows the chipper to get all around the work.

A good tool for cleaning out long holes and smoothing off rough spots in grooves or corners is a round tool with a flat end. For cleaning out burrs and slight fins in holes through thin sections a tool with a slow taper is very useful.

Many chippers damage their air hammers by not holding them firmly to the work. Using an air hammer in this way will very often break the handle where it is screwed to the barrel.

Tumbling.—Various-sized barrels should be used to secure the best results. The following practice produces a very good finish:—

Fill the barrel about one-third with jacks, pack the castings in tight, and throw in a discarded emery stub broken into pieces about the size of the fist with a little more than one-half pint of fuel oil. Tumble for three hours.

Care of Machinery and Tools.

To avoid delays and loss of tools every finishing department should have a tool-room in charge of a good man. It is not necessary to have a first-class mechanic; a good handyman will do if he is conscientious and interested in the work. While he should have the ability to make repairs, his main duty is to prevent them. He may be under the supervision of the mechanical department, but subject to the orders of the finishing department.

The tool-room may be about 8 ft. by 12 ft., and in it are all spare parts for the machinery, and tools can be kept in order. A place may be arranged where the men can store their tools at the end of the day. If such provision is not made a man who takes pride in his tools will invariably hide them, and in such a case, if he leaves overnight, the possibility is that the tools are lost.

We do not find it good policy to have a man grind tools for the chippers, because chippers invariably think no one can grind a tool as they can, and will invariably regrind it.

Inspection.

The best inspection is secured when every operator is trained to inspect his own work. This is accomplished by refusing to pay for work done on scrap castings. When an operator believes a casting to be defective he sets it aside until the foreman or a regular inspector comes around to pass on same. This slight delay is more than covered by the saving in labour to the operator and the company.

In some plants the inspection does not start until the castings are finished, whereas it should start on the knocking-out floor, or even in the foundry itself. A very good practice is to provide one or more places where scrap may be accumulated until it can be checked off and inspected by the shop foreman. Once this is done the scrap should be loaded immediately and sent to the yard. While the finishing department foreman cannot look at every casting that passes through his department he can and should inspect all scrap castings before they are sent to the yard. If he does this he is in a position to safely instruct all his men in the scrapping of doubtful castings.

In regard to castings being scrapped it is not good policy for the foundry foreman to have any authority in this question, because naturally he will be inclined to pass questionable material in order to hold his scrap down. This authority should be with the finishing department foreman, as he must take the blame for castings rejected by the customer. If the foundry foreman questions his decisions the case should be passed to the management for decision. This does not apply, of course, where an independent inspection bureau is maintained.

Cost.

One of the best methods for reducing costs is to furnish the finishing department foreman with an itemised cost of production semi-monthly. By this means he can watch the different items, such as labour, power and material, and thereby be able

to develop means for its reduction. Without furnishing him this information the management can hardly hold him responsible for his costs, nor does it do any good to furnish such information one or two months later, for by that time the foreman will have forgotten the conditions prevailing at the time and will no longer be interested.

The gang system is a big aid in reducing costs if the foreman will carry it through in the proper manner. By keeping the gang leaders advised whether their costs are up or down he gains their interest, and with a little diplomacy can create a friendly rivalry between the various gangs. This can be done without letting them know the actual cost per ton.

The cost of welding is a large item in every plant, and is always charged to the finishing department. This is really a mistake. The finishing department has absolutely no control over the amount of welding to be done, this being entirely against the foundry. If this cost was placed on the foundry the foundry foremen would have the same incentive to reduce welding costs as they have to reduce scrap.

Wages.

The matter of wages is always a delicate question. Some shops have been very successful in reducing costs by paying a higher rate of wages, thereby securing better workmen and having them satisfied. By so doing fewer men are required to get out a specified tonnage, and labour turnover is reduced. It is really cheaper to pay one first-class man twenty-five shillings a day than to pay two poor men twelve-and-sixpence each. The first-class man will produce the same amount as the two second-class operators, while at the same time only one set of tools need be maintained instead of two. Actually the saving in tools is more than this, since a good man takes better care of his tools and the cost of maintenance is thereby lowered. Also, the first-class operator will save more than 50 per cent. on other items, such as air, power, abrasives, welding rod, etc.

There seems to be a modern tendency to set an arbitrary hourly rate. This to us seems wrong, because all men are not alike; although an arbitrary rate tends to make them so, but in the wrong direction. The only incentive for the good man is to come down to the production level of a poor operator, which 90 per cent. of them do. The best practice is to establish a basic rate for starting, and later rate a man according to his ability.

It is poor policy to cut piece-work rates simply on the plea of excessive earnings. This kills the object of piece-work. If the rate is too high it is up to the foreman to devise some change in the operation that will give him reason for changing the rate. The real object of piece-work is to arouse the dormant ability of the operator. On an hourly rate the average man works automatically, while on piece-work he not only increases his physical effort, but his mental effort as well. He will change his tools, or his rigging, develop a systematic movement, and by other means increase his output. He is therefore entitled to whatever earnings he can make. Cut the rate and this spirit will be killed.

Foreman.

Most managements have long since ceased to give the finishing department a minor rating. Its influence on costs is well known, and the selection of a foreman demands careful consideration.

A finishing department foreman must have the full confidence of the management and receive authority equal to the responsibility placed upon him. Practically he should be able to do personally all the operations in his department in order that he may capably judge the output of his men and establish piece-work rates.

The foreman of a finishing department stands in a very difficult position, in that he must take castings from the foundry in whatever condition they are produced and make of them a product acceptable to the customer. If obliged to call the foundryman's attention to a poor lot of castings the only satisfaction he usually gets is to be told how it happened; and likely the next lot will be worse. At the same time, he can offer no excuse to the customer. It is quite possible that a little extra welding, grinding, or chipping may make a casting with surface defects look very creditable, and it is part of the foreman's duty to decide just how far to go in such cases without detriment to the buyer's interest. On the other hand, the foundry may produce very good castings which, if not properly finished, make a poor impression on the customer. It is obvious, therefore, that a finishing department foreman must be honest to the highest degree and conscientious in his work.

Conclusion.

In presenting the above ideas it is realised that some modifications may be necessary in order to adapt them to local conditions. Every foundry confronts its own peculiar problems; nevertheless, it is hoped that the suggestions herein may prove of general interest.

Importance of Temperature in Acid Open-Hearth Practice.

By E. G. Smith.

To obtain the maximum output of good steel from an acid furnace, the importance of working at as high a temperature as is consistent with the safety of the refractories cannot be too strongly emphasised. Some steel-makers are under the impression that it is more economical to lengthen the life of a furnace by cold-working; but they lose sight of the fact that they are obtaining a reduced output of steel which is not as free from "dirt" as it might be. The first essential in good acid practice is hot-melting, whereby is avoided an undesirable highly-oxidising melting slag which cuts the banks and often makes the bath "boil" without ore. Hot-melting is particularly necessary when in attempting to increase output the proportion of pig to scrap is lowered. After melting down, the next essential is a good, vigorous, hot boil obtained by the rapid feeding of ore, and maintaining a good heat in the furnace. A good boil not only facilitates the elimination of carbon, but also the transfer of heat from the flame to the metal, particularly desirable in low-carbon heats which are bottom cast.

A bath which is kept hot can be fed with ore and limestone with little danger of over-oxidation, since the added oxide of iron soon works off at the expense of the carbon, thereby accelerating the speed of working. Furthermore, a good dead-melt condition can be readily obtained by "stewing" for a short period without feeding, during which time the metal clears itself of suspended slag and non-metallic matter. The effects of high temperature in facilitating the production of good "condition" in the bath are threefold:—(1) Solubility of the iron oxide in the metal diminishes with rise in temperature; (2) gas oxidation of metal into the slag is diminished; and (3) reducing activity of carbon on oxide of iron is enhanced. If the necessary tapping heat is obtained in the metal during the boil, the melter can afford to reduce the temperature slightly at a period when there is most danger to the refractories, *i.e.*, when the slag has thickened and the bath has ceased to boil. When worked cold, a charge will not take much ore, and does not get on to a good vigorous boil, while the metal never properly frees itself of the oxide of iron necessarily present on melting; this results in dirty steel after the finishing alloys have been added.

What frequently happens as a result of cold-working is that, although not having given the bath much ore, the melter finds the carbon is down to the desired percentage, but the metal is short of heat and over-oxidised. After stewing and doctoring with pig and ferro-silicon, the charge may yield good metal samples, but at the same time it is highly charged with non-metallic products of deoxidation.

In the last endeavour to obtain sufficient heat for tapping, when the bath is not boiling sufficiently to absorb it, the furnace is often damaged more than if worked hot from charging to tapping. The advantages of hot-working may be summarised thus:—(1) Increased output as a result of quicker working and time saved in fettling cut banks and bad bottoms; (2) good dead-melted steel with a minimum amount of non-metallic inclusions; and (3) increased yield of metal, since gas oxidation of metal into the slag is diminished.

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Fireclays.

A METHOD OF ANALYSIS.

By Celsian.

Many works' chemists apply the same method of analysis to almost all classes of refractory materials. Best results cannot always be secured by working in this manner, and the estimations are often prolonged and inaccurate. Several advantages can be gained by making use of the principles pertaining to those constituents which are present in the largest proportion. That is, when dealing with material containing a high percentage of either silica, lime, magnesia, or alumina, special methods should be adopted whereby these compounds are completely precipitated and removed from solution without loss of time.

The following method gives an example of one of these processes as applied to the analysis of fireclays. The principle on which this method is based is that aluminium nitrate on heating is converted to the insoluble oxide, while calcium and magnesium nitrates remain practically unaffected. In the ordinary methods of analysis the alumina is precipitated with ammonia re-dissolved and precipitated again. This process is not only tedious, but there is a great risk of the large precipitate occluding small percentages of lime and magnesia, thus rendering the analysis inaccurate.

The Method.

Combined water and organic matter are estimated in the usual manner by igniting two grammes of the clay in a muffle furnace for about 20 minutes. The loss on ignition is reported as total water and organic matter. The dried sample is finely pulverised and bottled for further use (the bottling is practically unnecessary when dealing with firebricks). One gramme of the sample is weighed out and mixed with a fusion mixture as in the analysis of other refractories. The mixture most commonly used consists of five grammes sodium carbonate, five grammes potassium carbonate, and half a gramme of potassium nitrate. After thoroughly mixing up the sample with the fusion mixture, the whole is charged into a platinum crucible and dried. The crucible is then placed inside a muffle furnace, and the mass fused for about half an hour. When cold the melt is extracted with water in a beaker, an excess of nitric acid added, and the solution evaporated to dryness. The dry mass is baked for some time at a temperature of about 180 deg. C. Nitrous fumes are evolved and aluminium nitrate is converted to alumina. The small percentage of iron present in fireclay will exist here as ferric nitrate, but this salt decomposes at 125 deg. C. Ferric nitrate is first converted to a basic nitrate by the heating, and then loses more of its nitric oxide, the remaining salt existing almost entirely as ferric oxide. Calcium and magnesium nitrates remain unchanged by the heating. A small percentage of the alkalies is usually present in fireclays, and may exist here either as nitrate or oxide, both of which are soluble salts. The baked mass is cooled and digested in a concentrated solution of ammonium nitrate. Calcium and magnesium salts completely re-dissolve, the residue consisting of silica, alumina, and ferric oxide. (A minute percentage of iron salt may be re-dissolved, and this should be tested for in the filtrate.) The solution is filtered and washed with water containing a little ammonium nitrate.

Silica.

The precipitate is transferred to a small flask and boiled in hydrochloric acid containing a few drops of nitric acid. Unless the baking has been conducted at too high a temperature the oxides of alumina and iron will dissolve in a few minutes, leaving an insoluble residue of silica. The solution is filtered and washed, and the precipitate dried, ignited and weighed as silica.

Alumina and Ferric Oxide.

An excess of ammonium hydrate is added to the filtrate from the silica, and the solution boiled, filtered, washed, dried, ignited and weighed. This gives the combined weight of alumina and ferric oxide. The precipitate should be ignited at as low a temperature as possible, since if strongly heated it becomes less soluble. When cold the residue is dissolved in a little *aqua regia* or hydrochloric acid. Potassium permanganate solution is added drop by drop to the liquor until it is just tinted. Potassium thiocyanate solution is added, and the red colour produced is compared with that of a standard iron solution prepared under similar conditions. The percentage of ferric oxide computed is subtracted from the weight of the combined precipitate, giving the percentage of alumina present. By applying the thiocyanate method for estimating iron, accurate results will be secured, although very small percentages of that metal are present.

Lime and Magnesia.

To the ammonium nitrate filtrate from the insoluble residue, ammonium hydrate and ammonium oxalate are added. The solution is boiled, allowed to settle for some time, carefully filtered and washed (using double papers), ignited strongly, and weighed as lime. Ammonia and ammonium phosphate are added in excess to the filtrate, which is then warmed gently and well stirred. Better results can be secured for this precipitation by using ammonium sodium phosphate, but it is not suitable if the alkalies have to be determined in the filtrate. (This does not apply here.) If a slight precipitate forms on addition of the ammonia, it should be re-dissolved by adding an excess of ammonium chloride. After settling for some time the solution is filtered, washed with dilute ammonia, and the small precipitate dried, ignited, and weighed as magnesium pyrophosphate. This precipitate contains 36 per cent. magnesia.

The Alkalies.

Fireclays usually contain a small percentage of soda and potash, but in ordinary works' laboratories their presence is often disregarded, as a determination of these constituents often occupies more than one day. When dealing with material which does not require a preliminary fusion with an alkali fusion mixture, the filtrate from the magnesia is simply evaporated to dryness with sulphuric acid and baked. A few small lumps of pure ammonium carbonate are added, and the baking continued till no more fumes are evolved. The slight precipitate is weighed as sodium and potassium sulphates, and approximately calculated to their oxides, the result being recorded as percentage alkalies. The estimation of any rarer metals present is not detailed here, the object of the article being to show a rapid and accurate means of separating the ordinary constituents.

New British Chemical Standard Steel.

Messrs. Ridsdale & Company announce the issue of British Chemical Standard Carbon Steel "E." (B.C.H.), having the following standardised figures:—

Carbon	0.114 per cent.
Manganese	0.492 per cent.

This material has been specially prepared to meet the need for a widely recognised carbon (colorimetric) standard above 0.10 per cent., which is near to the maximum usually desired in tinplate manufacture. It has the additional convenience of being a low-manganese standard, so that those who prefer to determine the carbon (colour) and manganese from the same portion of sample may do so.

As usual, the analysis has been conducted by a number of independent analysts, works' chemists, etc. (including the Bureau of Standards, Washington, U.S.A.), representing different interests.

Bottles of standard turnings may be obtained from Headquarters, 3, Wilson Street, Middlesbrough, at a fee estimated to be sufficient to cover the cost of preparation. Three sizes are now provided, viz., 500, 100 and 50 grammes.

A certificate giving the names of the analysts co-operating, the types of methods used (including numerous notes thereon), and a detailed list of the individual analyses, will be supplied with each bottle.

Trade Talk.

Pease & Partners, Limited, have decided to stop their two furnaces at the Tees Ironworks.

Vincent Ogden & Company, of Walsall, have acquired lead mines in the Via Gellia Road.

An order for 7,000 tons of rails for the Bagdad Railway has been placed with a mill in the Saar district.

The South Wales steelworkers, under the sliding scale, will have their wages advanced 1 per cent. for the ensuing three months.

A Belgian shipping firm has placed an order for four ships of 1,800 tons net each with Swan, Hunter & Wigham-Richardson, Limited.

Fifteen hundred men employed at the Port Talbot steelworks of Baldwins, Limited, received 28 days' notice on October 6 owing to trade depression.

Sir W. G. Armstrong, Whitworth & Company's civil engineering department has secured the contract for the construction of the first section of the Shingmun Valley waterworks.

The council of the Institution of Civil Engineers have awarded a Telford Premium to Professor Louis N. G. Filon (London), and an Indian Premium to Mr. F. C. Temple (Jamshedpur, India).

D. Douglas Stewart & Company, metal and machinery merchants, have removed from Quay Parade, Swansea, to larger offices alongside their metal yard near West Pier, South Dock Basin, Swansea.

Before the members of the Hull Association of Engineers, recently, Mr. W. T. Athey delivered a lecture on "The Mechanical and Electrical Equipment of Docks." Mr. A. W. Gibson was in the chair.

Cochrane & Sons, Limited, of the Ouse Shipbuilding Yard, Selby, have received an order from Pickering, Haldane & Company, Limited, of Hull, for the construction of two steel screw trawlers. They will be 138 ft. long.

On Saturday, October 4, three special trains were chartered to convey some of the employés of the British Insulated and Helsby Cables, Limited, Prescot Factory, on the occasion of the firm's excursion to the British Empire Exhibition.

As anticipated, the result of the ballot of the 8,000 steel strikers at Rotherham and Stocksbridge, on the issue of a return to work on the employers' terms, pending further negotiations, has been in favour of this plan being adopted.

Owing to increasing business in the South Wales area, Johnson and Phillips, Ltd., electrical engineers and cable makers, Charlton, London, S.E.7, have removed their Cardiff branch offices and stores from 2a, Court Road, to more commodious premises at 10, Westgate Street, Cardiff.

Honeywoods (Supplies), Limited, 69, Bridge Street, Newport, Mon., have been appointed sub-agents in South Wales for the well-known engineering firm of D.E.M.A.G., of Duisburg, and also hold the agency of Heemaf, Holland, manufacturers of electric motors, etc., and that of Smeeton-Wright Furnaces, Limited.

Mr. C. Clayton, of Brooks, Phillips & Company, Limited, draws attention to the eighth annual whist drive, in aid of the funds of the Royal Metal Trades' Pension and Benevolent Society, which will take place (under the direction of the Auxiliary Committee) at Finsbury Town Hall, Rosebery Avenue, E.C.1, on Saturday, November 1.

Hollings & Guest, Limited, Thimble Mill Lane, Birmingham, inform us that, owing to the increased demand for their all-metal bundling press, they have been able to effect a reduction in the manufacturing costs, and have reduced the selling price from £18 net to £15 net f.o.r. Birmingham, or, if packed and delivered f.o.b. English port, to £18 net.

The Dublin dockyard was opened on October 6 by the new company, Vickers (Ireland), Limited, which recently acquired the premises. The more recently-constructed new yard at Alexandra Road conducted by Dublin Shipbuilders, which was also closed, is to be reopened under conditions similar to the arrangements at the Dublin dockyard premises.

Under an ascertainment issued by the Cleveland Ironmasters' Association, the wages of blast-furnacemen will be reduced by 3 per cent. as from October 5. This will bring the wages from 21.75 to 18.75 per cent. above the standard. The ascertained price of No. 3 Cleveland pig-iron was 83s. 3.79d., a reduction of 3s. 0.24d. per ton as compared with the previous quarter.

The sixth British Industries Fair (Birmingham) will take place from February 16 to 27, 1925, and will again be housed in the permanent Exhibition buildings at Castle Bromwich, in which there are over 170,000 sq. ft. available. The site adjoins Castle Bromwich Station (L.M. & S. Railway), and has its own sidings alongside the buildings in which the Fair will be held.

Institute of Metals.

North-East Coast Local Section.

A very successful meeting of the above was held at Armstrong College, Newcastle-on-Tyne, on Tuesday, October 7, the chairman, Professor H. Louis presiding. There was an excellent attendance to hear Professor F. C. Thompson, D.Met., B.Sc., of Manchester University, give his lecture on "The Structure of Metals in its Relation to Elastic Failure," which comprised the first part of a paper written under the joint authorship of Professor Thompson and Mr. W. E. W. Millington.

The lecturer, who illustrated his remarks by means of lantern slides, went very deeply into the question of the arrangement of atoms in various metals. He mentioned that the X-ray analysis of copper by Professor Bragg had shown that the atoms were arranged in a close-packed cubic space lattice in which each elementary cube possessed an atom at each corner and one at the middle point of each face. The author then went on to describe, with the aid of balls, two essentially different forms of deformation, which were termed "easy glide" and "slip." He pointed out that it was well known both to the crystallographer and metallographer that mechanical deformation of a crystal could produce twinning, but that the mechanism of the process had, in the past, been far from clear; at any rate, so far as the authors were concerned. The mutual attractions of the atoms of a metal were also touched upon.

A discussion followed, Professor Louis, Dr. Cook, Messrs. Fitt and Gibb being among the speakers. The lecture will be continued by Mr. Millington at the next meeting of the above Local Section, to be held on November 4.

The membership of the Local Section has considerably increased this year, no less than sixty new members having been enrolled already. Owing to ill-health, Mr. H. M. Duncan was compelled to resign the secretaryship at the end of last session. He is succeeded by Mr. E. G. Brownlow, of C. A. Parsons and Co., Limited, Heaton Works, Newcastle-on-Tyne.

Cyfarthfa Works to be Dismantled.

Following on their recent purchase of Bessemer's Bolton Works, it is announced that Thos. W. Ward, Limited, of Briton Ferry and Sheffield, have acquired the blast furnaces, blowing engines and stoves at Cyfarthfa, Merthyr Tydfil.

Founded in 1765, for more than a century and a-half the Cyfarthfa Works have been famous in the history of the iron and steel industry, and its fortunes have been governed by men of great force of character and commercial genius. At the close of the eighteenth century the works were probably the largest in the world, employing over 1,000 hands, and sending material to all parts of the globe. One hundred years ago the vast works found employment for 5,000 hands, and 6,000 tons of rails could be turned out in a single month.

When the iron age gave place to that of steel the entire iron plant at the Cyfarthfa Works was converted at immense cost to the Bessemer process. Until 1890 the works were in private hands, but in that year the proprietors turned it into a limited company, and about twelve years later the works were acquired by Guest, Keen & Nettlefolds, Limited. During the last decade the works have been carried on with varying success, much of their former glory having departed, although munitions kept them busy during the war. The works were closed down about five years ago, and Thos. W. Ward, Limited, will add another name to the list of famous works which they have dismantled.

A licence under the Non-Ferrous Metal Industry Act, 1918, has been granted to Krogsdal, Waldemar Jensen, 39, Clarence Chambers, Corporation Street, Birmingham.

For some time past Mr. Charles Markham has been considering the question of merging the business of Markham & Company, Limited, engineers, Chesterfield, in the Staveley Coal and Iron Company, Limited. Mr. Markham has now decided to carry through the project. The present business will be carried on at Chesterfield. There has been a close working relationship between the two concerns for some time.

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Movements in the Cleveland iron market continue without any striking developments, the position at the moment reflecting quiet, but steady, conditions, which are unlikely to undergo material change until the turmoil of the forthcoming election has subsided, and the political situation has become more definitely decided. With regard to foundry iron, the present output is comparatively small, and the quantity available for the market is still smaller, as in one or two cases makers are using up the bulk of the production in their own works. Moreover, the accumulations in the yards are not large, and a considerable proportion of the stock represents iron sold at a high price which has not yet been taken out. Although the consuming industries are by no means well off for orders, matters are perhaps a little better than they were in the marine engineering foundries, and, with pig-iron prices more stable, it is not unreasonable to anticipate some improvement in buying. There has, for instance, again been a rather better inquiry from Scotland. At this week's market No. 3 G.M.B. was firmly held at 80s. per ton, No. 1 being about 85s., No. 4 foundry 79s., and No. 4 forge 78s. per ton.

The continued decline in demand for hematite is emphasised in the fact that a further suspension of furnace operations is reported on Tees-side and in South Wales, while it is currently stated that other stoppages of production are in contemplation elsewhere. The fact is that for a very long time production has been much in excess of demand. Makers have kept going in the hope of an improvement in business, but stocks have at last become so unwieldy that they have been compelled to curtail production. Unfortunately, the home trade as yet shows no substantial sign of expansion, while exports are far below normal. With regard to prices, East Coast mixed numbers can now be done at 87s. per ton, which is again a shilling reduction on the previous week, No. 1 being 87s. 6d. per ton. Conditions in the West Coast area are about the same as at Tees-side, with prices inclining to weaker levels, Bessemer mixed numbers being quoted nominally at 102s. per ton delivered at Glasgow, 108s. 6d. per ton at Sheffield, and 113s. 6d. per ton delivered at Birmingham.

LANCASHIRE.—The local market for foundry pig evidences little improvement in the general position, the fall in Cleveland iron prices encouraging consumers in the district to hold off until better terms for Midland brands are available. So far, Derbyshire No. 3 pig-iron has not yet been offered freely at Manchester at 90s. per ton, delivered, but sellers are now not much above this price, and it would not be surprising to see it established in the near future. The position in Scotch pig-iron is again weaker, and although at the furnaces 90s. per ton is asked, orders for good brands have been taken locally on a lower basis. Probably about 107s., delivered in Manchester, for good brands of Scotch No. 3 would be a fair price now.

THE MIDLANDS.—At Birmingham last week the market was somewhat indefinite in tone, but the demand for foundry pig continues dull, the reduced prices not having effected any improvement. It might be said that the reverse is the case, as consumers are holding off until it is possible to ascertain the lowest quotation. Current quotations for pig-iron are as follow:—Derbyshire No. 3 foundry, 82s. to 85s.; Staffordshire No. 3 foundry, 85s.; Northants No. 3 foundry, 75s. to 79s.

SCOTLAND.—Markets throughout this area remain dull and uneventful, very little buying of foundry pig being reported while prices continue to weaken, 90s. per ton having been accepted lately for No. 3 quality. Consumers are still content to go from day to day, and there seems to be no improvement in the condition of their order-books to give them courage to go into the market for good parcels. As far as Scotch iron is concerned, there are no signs of the seasonal buying coming on which is generally expected at this time.

Finished Iron.

In this section of the market marked bars appear to be the only class of material with any noticeable signs of activity, and even in this direction makers are not so busy as they were two months ago, having worked off a large portion of the wagon orders. There is, however, a steady demand. The call for crown iron is still very disappointing and the recent depreciation in values, making the present figure of £12 10s. to £12 15s., has not brought in much additional support. With such a disparity of over £3 per ton between English iron and steel, it is certain that steel will be utilised wherever possible.

Steel.

In the market for steel and its products makers of billets are experiencing a sharp slump, and the falling off of business applies almost equally to basic and acid qualities. The Continental supplies are below the prices of English billets, but they are not suitable for the best quality work turned out by Sheffield manufacturers. Finished steel products have been reduced 10s. per ton. There is less buying of high-grade steels than has recently prevailed, though overseas trade is keeping up fairly well. Business in ferro-alloys is again on the slow side, neither producers nor consumers being apparently eager to close transactions at the moment. Ferro-manganese is, however, now quoted at very low prices on the Continent, in the absence of demand. For tinplates the price is maintained at 23s. 6d.

Scrap.

Business in this class of material is again reported idle, with a very substantial absence of the seasonal demand for metal usually experienced in the autumn. In Lancashire good broken machinery scrap has, before now, been worth as much as foundry pig-iron, and may be again, but, of course, not when the supply of the scrap is very much greater than the demand. One does hear occasionally of the acceptance of 80s. at Manchester for cast scrap, but the usual quotations now are from 82s. 6d. to 85s. In the Scottish markets also conditions are dull, while machinery cast-iron scrap is not retaining its price in the same capacity as pig-iron, and first quality changed hands last week at 83s. 6d. per ton. Ordinary cast-iron scrap, in pieces not exceeding 1 cwt. and suitable for foundries, is 80s.

Metals.

Copper.—The tone of the market for standard copper of late has evidenced a slightly easier tendency, with buying on a more restrained scale than has been experienced during the past few weeks. The absence of copper statistics is very disconcerting, the trade being without real information as to the actual position. It is rumoured, however, that producers have been increasing production, and it is feared that surplus stocks have been substantially increased. The fact has aroused attention that in the open market a line of 500 tons of specifiable electrolytic changed hands between dealers on the basis of £66 10s. c.i.f. Current quotations:—*Cash*: Thursday, £61 15s.; Friday, £62; Monday, £62 7s. 6d.; Tuesday, £62 10s.; Wednesday, £62 17s. 6d.

Three Months: Thursday, £62 15s.; Friday, £63; Monday, £63 7s. 6d.; Tuesday, £63 10s.; Wednesday, £63 17s. 6d.

Tin.—Movements in this section of the market recently have had a rather irregular tendency, with prices fluctuating within narrow limits, the "bulls" having for the time being slightly the best of the argument with their "bear" antagonists. The future course of the market would seem rather problematical for the moment, and the uncertainty in regard to the outcome of the monthly statistics did not help. It was considered that the visible supply might possibly disclose a moderate decrease in view of a reduction in the Straits shipments, which have been latterly estimated at about 5,000 tons, and this view proved accurate. Current quotations:—*Cash:* Thursday, £241 10s.; Friday, £244 5s.; Monday, £245 5s.; Tuesday, £245 5s.; Wednesday, £244 15s.

Three Months: Thursday, £243 15s.; Friday, £246 10s.; Monday, £247 5s.; Tuesday, £247 12s. 6d.; Wednesday, £247 10s.

Spelter.—Consumptive demand for the metal at present is somewhat below the average, but the general tendency seems in the direction of improvement, although the position is not likely to change much. Possibly we shall see some improvement, however, this month when trade buying sets in. The statistical position seems sound enough. Lately the market has been quiet and inclined to fluctuate. Current quotations: — *Ordinary:* Thursday, £33 2s. 6d.; Friday, £33; Monday, £33 6s. 3d.; Tuesday, £33 7s. 6d.; Wednesday, £33 6s. 3d.

Lead.—The market for soft foreign pig has been without outstanding features of interest, but the position is well controlled. Trade buying is rather quiet at the moment, but the Continent looks like taking more. The financing of important quantities is not a good feature, especially under the present highly-inflated level of prices. Current quotations: *Soft foreign (prompt)*: Thursday, £34 17s. 6d.; Friday, £34 15s.; Monday, £34 17s. 6d.; Tuesday, £35 5s.; Wednesday, £35 13s. 9d.